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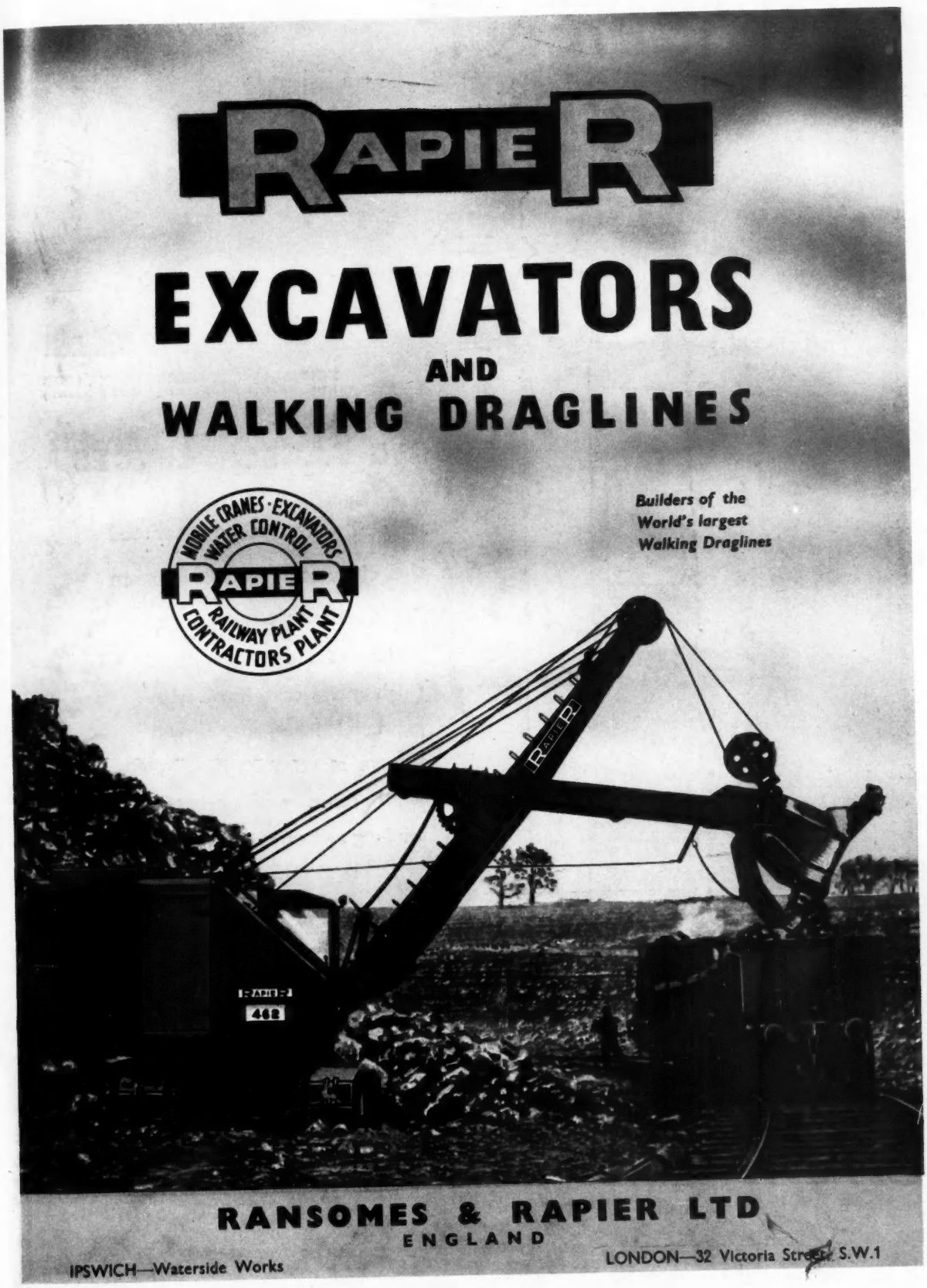

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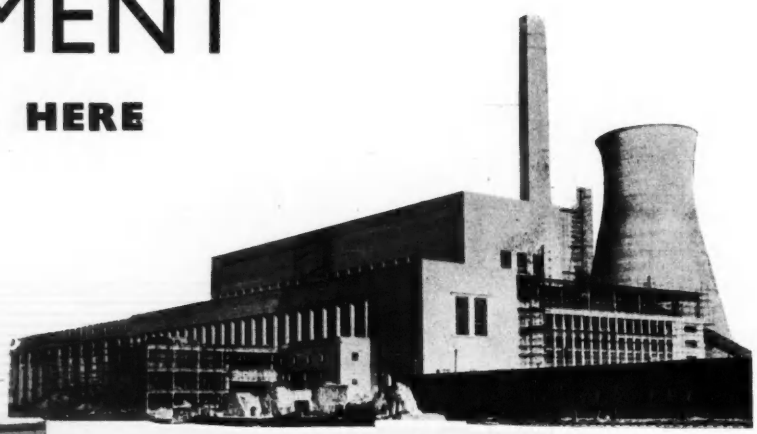

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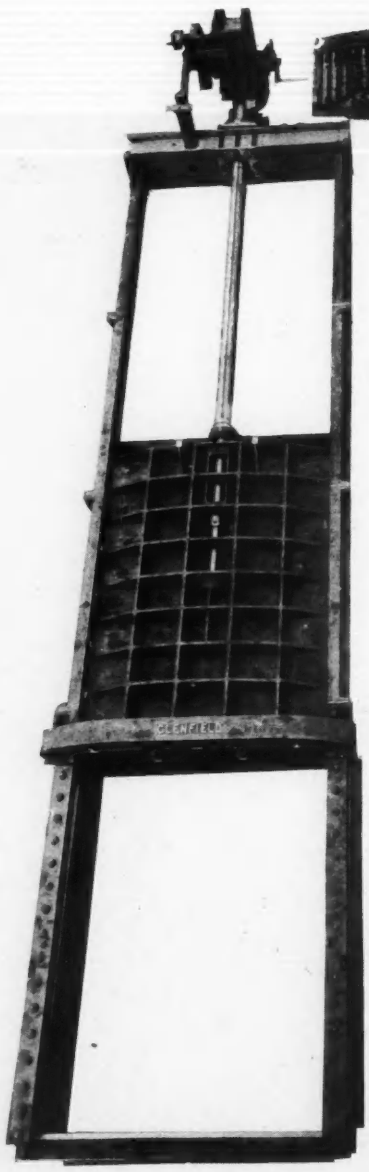

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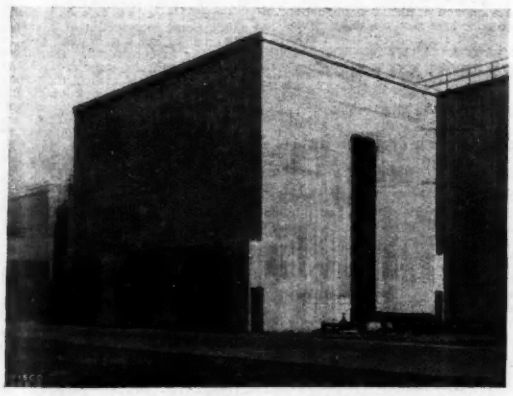

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THE ENGINEER

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF ADELAIDE

SOUTH AUSTRALIA

LECTURER IN CIVIL ENGINEERING

Applications are invited for a LECTURER in CIVIL ENGINEERING (preference will be given to a candidate whose interests lie in hydraulics and soil mechanics, but other candidates are encouraged to apply).

Salary scale : Lecturer, £600 by £50 to £1000. A cost-of-living allowance of £228 per annum is at present payable.

A superannuation scheme corresponding to F.S.S.U. is available. Promotions depend upon merit and accomplishments rather than on seniority. Study leave is regarded as important.

Detailed terms of appointment will be supplied on request to the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1, or to the undersigned.

Applications : Applications in duplicate must include particulars of age, nationality, academic record, teaching qualifications, war service (if any), and present position ; a list of publications (if any) ; copies of testimonials ; the names and addresses of two referees, of whom confidential inquiries may be made ; a recent photograph ; and a medical certificate of good health ; and should reach the undersigned not later than May 31st, 1953.

A. W. BAMPTON,
Registrar.

University of Adelaide,
Adelaide, South Australia. E8394

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF ENGINEERING PRODUCTION

STAFF OFFICER

Applications are invited for the following positions at the new Engineering Production Institute, now being developed by the University of Birmingham :—

ONE STAFF OFFICER, to undertake responsibility for the organisation of courses of study for senior engineers and executives and for lecturing and advanced group studies in work study, operational research and other engineering production and management subjects.

ONE STAFF OFFICER, to undertake the duties of bursar, librarian and information officer and, in addition, to direct advanced group work on production research and development studies.

Salary in each case according to qualifications and experience. The appointment will be for two years in the first instance, subject to review. Applications in triplicate, stating age and full details of previous academic and industrial career, should be sent on or before 9th May, 1953, to the Registrar, The University, Edgbaston, Birmingham, 15.

C. G. BURTON,
E8388 Secretary.

UNIVERSITY OF HONG KONG

LECTURESHIPS

Applications are invited for the following vacant posts in the Department of Civil Engineering :—

(a) SENIOR LECTURESHIP in CIVIL ENGINEERING. Salary for a single man on expatriate terms £1405 by £40 to £1565 per annum (plus a family allowance of £170 per annum for a married man).

(b) LECTURESHIP in CIVIL ENGINEERING. Salary for a single man on expatriate terms £1240 by £40 to £1480 per annum (plus a family allowance of £160 per annum for a married man).

Applicants must be Graduates of a British University and should have special interest in either soil mechanics or surveying. Preference will be given to Corporate Members of the Institution of Civil Engineers.

The University provides first-class sea passages and accommodates expatriate staff in Hong Kong at reasonable rentals.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in London and Hong Kong, is 15th June, 1953. E8395

UNIVERSITY OF BIRMINGHAM

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING

Applications are invited from men with a good University Degree in Chemical or other branch of Engineering or in Chemistry for the ESSO STUDENTSHIP in CHEMICAL ENGINEERING, founded by the Esso Petroleum Company, Limited, commencing in October, 1953. The value of the Studentship is £350 a year plus University fees.

Applications should be submitted to the Registrar by 15th June, 1953, giving full particulars of educational qualifications, industrial experience (if any), national service, and outside interests, together with the names of two referees. E8416

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

SENIOR RESEARCH ASSISTANT

Applications are invited for the post of SENIOR RESEARCH ASSISTANT. Candidates should have a good Honours Degree in Engineering, practical experience and/or research training. Salary scale £550 by £50 to £900. Conditions of appointment and form of application may be obtained from the undersigned.

H. PICKBOURNE,
E8450 Registrar.

THE UNIVERSITY OF LEEDS

POWER-GAS CORPORATION SCHOLARSHIP

Applications are invited for the above SCHOLARSHIP of the value of £150 a year, which has been provided to enable suitably qualified students to undertake a course of study leading to a Degree in either Gas Engineering, Chemical Engineering, Mechanical Engineering or Civil Engineering in the University.

Preference will be given to candidates who reside within the Borough boundaries of Stockton-on-Tees or Thornaby-on-Tees, or who attended a grammar or secondary school in Stockton or Thornaby, or who are either employees or the children of employees of the Power-Gas Corporation, Ltd., or of Messrs. Ashmore, Benson, Pease and Co., Ltd. Applicants should be under the age of 19 on 1st October, 1953.

Applications should reach the Registrar, from whom further particulars and forms of application may be obtained, not later than 30th June, 1953. E8446

THE UNIVERSITY OF MANCHESTER

TWO LECTURESHIPS IN ENGINEERING

Applications are invited for two LECTURESHIPS IN ENGINEERING. Candidates should have special qualifications in mechanical engineering with particular interest in one or more of the following :—Fluid mechanics and heat transfer, thermodynamics applied to heat engines, theory of machines, the engineering of chemical processes. Salary scale £500–£1100 per annum, with membership of F.S.S.U. and children's allowance scheme. Initial salary according to qualifications and experience.—Applications should be sent not later than 16th May, 1953, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained. E8332

HER MAJESTY'S COLONIAL SERVICE

NYASALAND

VICE-PRINCIPAL OF DEDZA SECONDARY SCHOOL

There is a vacancy for a VICE-PRINCIPAL of Dedza Secondary School in Nyasaland.

Candidates should be between 32 and 40 years and should possess a B.Sc. (Engin.) or professional qualification (e.g., A.M.I.Mech.E.), together with teaching experience in a Polytechnic or Technical Secondary School. The candidate appointed will be mainly concerned with technical courses in mechanics, building and carpentry.

Appointment is permanent and pensionable, but temporary terms may be offered under the arrangements for the release of teachers to Colonial appointments for a period of up to five years. In either case superannuation rights may be safeguarded by arrangement with the Ministry of Education or Scottish Education Department. Salary £900–£1140 plus a variable cost-of-living allowance. Free medical attention. Quarters at low rentals. Free passages for officer, wife and children up to cost of three adult fares in all. Tour of service 2–3 years. Generous home leave. Income tax at local rates lower than in United Kingdom.

Further particulars and application forms obtainable from the Director of Recruitment (Colonial Service), Colonial Office, Great Smith Street, London, S.W.1. Reference CDE 114/4/03 should be quoted. Closing date for receipt of initial inquiries 30th May, 1953. E8389

ESSEX

THURROCK TECHNICAL INSTITUTE, GRAYS

ASSISTANT TEACHER (GRADE A)

Qualified Man ASSISTANT TEACHER (Grade A) required for engineering subjects to S.2 Standard and later beyond.

Salary £415 by £18 to £670 per annum. Increments allowed for recognised previous service and war service. Additions for Degree (or equivalent) and recognised training.

Application forms and further particulars obtainable from the Divisional Education Officer, Upminster Court, Hall Lane, Upminster, Essex, and returnable by 11th May, 1953. E8460

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal : G. E. WATTS, M.A., Ph.D. (Cantab), B.Sc. (Lond.), F.R.I.C.

LECTURER IN PRODUCTION ENGINEERING

Qualified and experienced LECTURER IN PRODUCTION ENGINEERING required to undertake work up to H.N.C. standard. Salary £940 by £25 to £1040.

Further particulars and application forms obtainable from the undersigned on receipt of stamped, addressed, foolscap envelope. Completed forms to be returned to the Principal, Brighton Technical College, Brighton, 7, within 14 days.

W. G. STONE,
Director of Education.

54, Old Steine,
Brighton, 1. E8373

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE

FARNBOROUGH, HANTS.

Farnborough, Hants, Royal Aircraft Establishment Technical College requires :—

LECTURER in AIRCRAFT STRUCTURES, to teach subject to Final B.Sc. (Eng.) and H.N.C. standard. Facilities for research may be available. Quals.: Degree with considerable teaching and industrial or research experience.

ASSISTANT "B" in ELECTRICAL ENGINEERING, to teach subject to H.N.C. and possibly Final B.Sc. (Eng.) standard. Facilities for research may be available. Quals.: Degree or equivalent in Electrical Engineering, preferably with industrial experience.

ASSISTANT "A" in ENGINEERING DRAWING, to teach subject to O.N.C. standard. Ability to teach elementary workshop technology an advantage. Quals.: Engineering Degree or equivalent, preferably with teaching or industrial experience.

DEMONSTRATOR in ELECTRICAL ENGINEERING and PHYSICS, to assist in organisation, preparation and control of work in electrical laboratory (to B.Sc. standard) and in physics laboratory (to Inter. B.Sc. standard). A little teaching may be involved. Facilities for research or further study may be available. Quals.: Electrical Engineering Degree or equivalent, preferably with industrial experience.

DEMONSTRATOR in MECHANICAL ENGINEERING, to assist in organisation, preparation and control of work in engineering laboratories (materials, metallurgy, metrology, heat engines, aerodynamics) to Final B.Sc. (Eng.) standard. A little teaching may be involved. Facilities for research or further study may be available. Quals.: Engineering Degree or equivalent, preferably with industrial experience.

Salaries on Burnham Scales for Technical Colleges with appropriate allowances for training, experience, &c., and subject to usual deductions for superannuation.

Details and forms from Principal, to whom completed forms must be returned within fourteen days of this notice. E8414

PETERBOROUGH JOINT EDUCATION BOARD

PETERBOROUGH TECHNICAL COLLEGE

FULL-TIME ASSISTANT TEACHER (GRADE B)

Applications are invited for the post of Full-Time ASSISTANT TEACHER (Grade B) in the Engineering Department. The successful candidate must be able to teach Production Engineering subjects up to Higher National Certificate level and should have had good industrial experience. Some teaching experience is also desirable. Salary will be in accordance with the conditions of the Burnham Technical Report.

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed, foolscap envelope. Application should be made within fourteen days of the appearance of this advertisement.

LESLIE TAIT,
Education Offices, Chief Education Officer.
Town Hall,
Peterborough. E8377

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING

Applications are invited from men with an Honours Degree in Chemistry or Engineering for the ESSO STUDENTSHIP, founded by the Esso Petroleum Company, Limited, tenable in the Department of Chemical Engineering at the above College from October 6th, 1953. The value of the studentship is £350 a year plus College fees.

Applications should be submitted to the Registrar, Imperial College, London, S.W.7, by 1st June, giving full particulars of previous industrial experience (if any), national service, and academic qualifications. The names of two references should also be given. E8417

CENTRAL ELECTRICITY BOARD

FEDERATION OF MALAYA

OPERATION AND EFFICIENCY ENGINEER

OPERATION and EFFICIENCY ENGINEER required by the Central Electricity Board, Federation of Malaya. Salary (including allowances) payable in local currency equivalent at present Government rate of exchange to £1687, rising to £2100 a year. Option of appointment either (a) on agreement for three years in the first instance, leading, subject to satisfactory service, to an offer of permanent employment on the pensionable establishment, with opportunity of terminating appointment at the end of the first year's service if so desired ; or (b) on contract for three years with a gratuity at the rate of £200 or £280 a year, according to salary. Allowances, additional to those mentioned, ranging between £210 and £630 a year are payable to married men according to salary and dependants. Free passages. Liberal leave on full salary. Candidates must have had good power station experience, including some years as a charge engineer in a modern steam station, and have a knowledge of the principles of combustion, thermal cycles and heat balances, system control, and the economics of operation. Candidates should preferably be Corporate Members or Graduates of the Institutions of Electrical or Mechanical Engineers or hold an equivalent qualification. Those who are not so qualified would be eligible for salary on a lower scale equivalent to £1673, rising to £1862 a year.—Apply in writing to the Crown Agents, 4, Millbank, London, S.W.1 stating age, name in block letters, full qualifications and experience, and quoting M2C/28770/EH. E8390

HER MAJESTY'S COLONIAL SERVICE

NIGERIA

EDUCATION DEPARTMENT

A PRINCIPAL OF A TRADE CE

A vacancy exists in the Education D Nigeria, for a PRINCIPAL of a Trade Ce Candidates should preferably be under age and should possess a University Degre anical Engineering, or an equivalent qu and have had considerable experience methods of apprenticeship training, and trial experience. Duties would include th tion and supervision of all workshops for of apprentices in the various branches of and engineering trades.

Post is permanent and pensionable, period of probation, or may be made on terms, if desired. Arrangements can be Home Education Authorities for the teachers to Colonial appointments for a p to five years, and superannuation rights guarded by arrangement with the Education.

Salary £1680 inclusive on pensionable £1870 plus resettlement grant on satisfa pletion of temporary agreement. Quart rental. Free passages for officer and appointment and on leave and for two allowance in lieu (subject to a maximum each child). Income tax at local rates, United Kingdom. Tour of service Generous home leave.

Applicants should write for a form and further particulars to the Director ment (Colonial Service), Colonial Office Buildings, Great Smith Street, Londo quoting reference CDE.114/14/01. Closi the receipt of initial inquiries 30th May,

WELSH REGIONAL HOSP BOARD

ASSISTANT ENGINEER (MECHA

Applications are invited for the followi the Engineer's Division :—

ASSISTANT ENGINEER (Mechanical cants must have had a sound technical mechanical engineering and experience in tion of estimates, specifications and steam boiler plant, central heating, hot and ventilating systems, and must be Members or Graduate Members of the Mechanical Engineers or have passed the examinations, or Corporate Members of tion of Heating and Ventilating Engineers

The salary scale will be £600 by £25 (7) by £865, the point of entry being according to at full professional standard.

The appointment is superannuable and by one month's notice on either side.

Applications, stating age, experience, qua and present position, together with the addresses of two referees, should be addres Secretary, Welsh Regional Hospital Board of Peace and Health, Cardiff, so as to reach later than ten days from the appearance advertisement.

CIVIL SERVICE COMMISSI

D.S.I.R.

NATIONAL PHYSICAL LABORAT

SUPERINTENDENT OF THE AERODYNAMICS DIVISION

The Civil Service Commissioners invite tions for the pensionable post of SU TENDENT (Deputy Chief Scientific Officer) dates must have been born on or before 31st ber, 1921. They must have a First or Seco Honours Degree in a Science subject or eq qualifications, provided that a candidate this qualification but of high professional ments may be considered. They should h siderable research experience in aero ability to direct and control the work of a staff and a broad outlook on the possib research applied to industry. The Aero Division is mainly concerned with theoret experimental research on high-speed and l aerodynamic problems.

Inclusive London salary (men) £195 (women) £1775–£2050.

Further particulars and application for Civil Service Commission, Scientific Branch, House, Old Burlington Street, London, W.1, No. S4201/53. Application forms to be ret 21st May, 1953.

WEST MIDLANDS GAS BOA

BOARD HEADQUARTERS

CONSTRUCTIONAL ENGINE

Applications are invited for the appoint CONSTRUCTIONAL ENGINEER Headquarters located in Birmingham.

Candidates must have had a wide expe constructional engineering in the gas industry

The salary offered is £2000 per annum, pensionable, and the successful candidate required to pass a medical examination.

Applications, stating age, qualifications rience, together with the names of two should be addressed to the Industrial Officer, West Midlands Gas Board, 6, Road, Edgbaston, Birmingham, 15, to within fifteen days of the appearance of tisement.

F. H. CURETON,
E8378 Secretary to the

THE ENGINEER

MAY 1, 1953

The British Non-Ferrous Metals Research Association

THE annual general meeting of the British Non-Ferrous Metals Research Association was held in London on Wednesday, April 22nd. The thirty-third annual report of the council, which was presented at the meeting, describes the progress of the Association's work, and emphasises that the advantages to be derived from the utilisation of available materials in the most economical way have not diminished. The use of available knowledge for the reduction of waste, the report says, remains one of the important points in the Association's programme. In the course of a statement at the meeting, Lieut.-Colonel the Hon. R. M. Preston, chairman of the council, said that thirty-two main researches had been included in the programme during the past year, six of which had been terminated or suspended. This year, eleven new researches had been started. Referring in particular to the Association's long-term researches, Lieut.-Colonel Preston said that one example was an examination of the properties of titanium alloys. He pointed out that titanium was not likely to become a common industrial material in a few years' time, but it was evident that its use for special purposes was going to increase rapidly. Following the meeting, the Association's annual luncheon was held at the Savoy Hotel, with Lieut.-Colonel Preston in the chair. The principal guest was Mr. A. R. Low, Parliamentary Secretary to the Ministry of Supply, who proposed the toast "The British Non-Ferrous Metals Research Association." Praising the work of the Association, Mr. Low said that we should grow richer in the next fifty years, not because of the material resources of this country or even of the Commonwealth, but because of the fullest use of the scientific knowledge that had been built up here. After a reply by the chairman, the toast of "The Guests" was proposed by the Hon. John Grimston, and acknowledged by Professor Sir Ian Heilbron, F.R.S.

Lloyd's Register of Shipping

LLOYD'S REGISTER OF SHIPPING has issued its shipbuilding returns for the quarter ended March 31st, which show that the work in hand consisted of 323 steamships and motorships of 2,132,903 tons gross, representing a decrease of 13,499 tons compared with the previous quarter. During the quarter, fifty-one ships of 305,343 tons were commenced, forty-seven ships of 227,691 tons were launched, while the ships completed totalled sixty-four of 310,821 tons. Oil tankers of 100 tons and upwards represented 57·5 per cent of the total tonnage under construction at 111 ships of 1,225,777 tons. For the second successive quarter there was a decrease in the tonnage of orders outstanding, plans having been approved or material ordered for 2,454,894 tons, a decrease of 151,548 tons from the preceding quarter. Of this tonnage the proportion of oil tankers has risen from 61·5 to 62·6 per cent. Abroad, excluding China, Poland and Russia, 879 ships of 3,871,854 tons were under construction, a decrease of 100,329 tons compared with the quarter ended December 31st. Progress during the quarter is represented by a total of 227 ships of 820,174 tons commenced, 203 ships of 835,713 tons launched, and 196 ships representing 909,737 tons completed. Oil tankers, which represented 52·7 per cent of the tonnage building abroad, totalled 185 ships of 2,041,482 tons. The total world construction amounted to 1202 steamships and motorships of 6,004,757 tons, of which 35·5 per cent was being built in Great Britain and Northern Ireland, which shows a decrease of 113,828 tons as compared with the previous quarter. Of the tonnage under construction abroad, 1,775,328 tons were steamships and 2,096,526 tons were motorships, the corresponding figures for Great Britain and Northern Ireland being 1,035,958 tons and 1,096,945 tons respectively. Oil tankers building amounted to 296 ships of 3,267,259 tons, which was less than the previous quarter by 19,990 tons, and represented 54·4 per cent of the total tonnage under construction.

Institute of Fuel Annual Luncheon

NEARLY 600 members and their guests attended the annual luncheon of the Institute of Fuel, which was held on Thursday of last week at the Connaught Rooms, Great Queen Street, London, under the chairmanship of the president, Dr. G. E. Foxwell. Following the loyal toast, a toast was given in honour of H.R.H. The Duke of Edinburgh, who has become an Honorary Member of the Institute, and the Melchett Medal for 1953 was presented to Dr. Harold Hartley. The Minister of Fuel and Power, Mr. Geoffrey Lloyd, in proposing the toast of "The Institute of Fuel," suggested that the Institute should adopt a number of worthies and put forward the names of Benjamin Franklin, the earliest fuel technologist, and Stanley Jones, who 100 years ago predicted that coal was not an unlimited asset. The gradual increase in coal production in the U.S.A. was mentioned by the Minister, who pointed out that American production was now many times that of ours, and that Russia now had a bigger output. Both countries, he continued, had a much greater fuel potential than Great Britain, so that in the light of modern indices of power, fuel technologists had an exacting scientific job to perform. The president replied and said that to supply 50,000,000 people with an element which was becoming rarer made it necessary to seek new knowledge and to remove ignorance. Continuing, he discussed the work of the Ministry of Fuel and Power, the professions, the colleges and the research teams, whom he called the Four Horsemen of the modern Apocalypse. Dr. Foxwell went on to stress the need for more trained fuel technologists, a need which was shown to be justified by the work of the productivity teams.

Institution of British Agricultural Engineers

THE eighth annual general meeting of the Institution of British Agricultural Engineers was held in London on Wednesday last. The report of the council for 1952, which was submitted to the meeting, shows that the Institution continues to make steady progress and that its membership is increasing. During the year, there were 195 elections to the various grades of the Institution's membership, bringing the total at December 31st last to 1106. Early last year, Mr. R. E. Slade was appointed secretary of the Institution. As well as recording a full programme of general meetings and meetings of the five local centres, the annual report gives an account of the Institution's other educational activities. Last year, twenty-one candidates sat for the examination for the National Diploma in Agricultural Engineering, ten of whom were successful in gaining the Diploma. At the meeting on Wednesday, Mr. D. P. Ransome, M.I.Mech.E., was elected president in succession to Mr. F. E. Rowland, M.I.E.E., who has occupied that office for the past two years. Since 1946, Mr. Ransome has been managing director of E. H. Bentall and Co., Ltd., prior to which he held various appointments with Ransomes, Sims and Jefferies, Ltd., of which firm his great-great-grandfather was the founder. Mr. Ransome is a member of the council of the Agricultural Engineers' Association, a member of the British Standards Institution's Engineering Divisional Council, and chairman of the B.S.I. committees on agricultural machinery and implements. It was also announced at the meeting that Mr. C. B. Chartres, M.I.E.E., a past-president of the Institution, had been elected to honorary membership.

Technical Aid to S.E. Asia

As part of the Colombo Plan, there was set up in 1950 the Council for Technical Co-operation in South and South-East Asia. The Council's report for the year 1952 was published as a White Paper, at the end of last week, by H.M. Stationery Office. The Council's business is to administer the technical co-operation scheme under which member countries of the Colombo Plan are able to obtain the services of experts for their development projects, facilities for training in the technically more advanced Commonwealth countries, and equipment for setting up and expanding training and research institutes of their own. The report shows that last year ninety experts were provided as well as facilities for 538 trainees. Most of the experts were engaged on projects where their duties included the training of local personnel, and the report notes that this was particularly so in the case of engineers for river valley projects in India, irrigation schemes in Ceylon, and a director for a bacteriological laboratory in Pakistan. Moreover, experts whose primary duties were to be the training of local personnel were in increasing demand. India, for example, asked for a tool-room foreman for the Indian Institute of Technology at Kharagpur, and Pakistan asked that a United Kingdom specialist who reported on the establishment of new telecommunications schools should return for two years, with the necessary equipment, to put his recommendations into effect. The report records a steady increase in 1952 in the demand for and provision of equipment for use by experts and for training and research institutions. It says, for instance, that the Government of Pakistan plans to set up a number of technical high schools. The United Kingdom has agreed with the Pakistan Government to provide the entire equipment for eight of these new schools and to supplement the equipment at a school already established in Karachi. The United Kingdom is also supplying tool-room equipment to the value of about £35,000 to the Indian Institute of Technology at Kharagpur.

The Work of Aslib

THE annual report of Aslib, which covers the year ended December 31, 1952, says that in spite of less encouraging conditions generally, the rate of development achieved in 1951 was maintained in most departments and increased in some others. At the end of the year, the membership of Aslib stood at 1434, compared with 1219 a year earlier. The report surveys the conferences organised by the Association during the year, and other educational activities undertaken in the interests of the staffs of special libraries and information departments. The number of general inquiries dealt with in the year, other than inquiries directed to Aslib's documentary reproduction section, was 7662, which represented an increase of no less than 117 per cent when compared with 1951. A new development during the year was the establishment, with the aid of a special grant from the Department of Scientific and Industrial Research, of a consultant service to give authoritative advice on the organisation and efficient conduct of special libraries and information departments. Reference is also made in the report to the work of the specialist groups which Aslib has formed. Last year, two new groups, concerned with fuel and power and engineering, were added to those dealing with textiles, economics, aeronautics, and food and agriculture, thus bringing the total number up to six.

British Industries Fair

No. II—(*Continued from page 586, April 24th*)

THE British Industries Fair opened at Castle Bromwich, Earls Court and Olympia, on Monday, April 27th, and remains open until Friday, May 8th. A further selection of the exhibits (at Castle Bromwich unless otherwise stated) is described herewith.

C. Tennant, Sons and Co., Ltd.

A direct reading portable hardness tester known as the "Indentometer" and made by the Cabul Tool Company, Ltd., is to be exhibited by C. Tennant, Sons and Co., Ltd., 4, Copthall Avenue, London, E.C.2. In this instrument there is used a 120 deg. cone diamond indenter, which can be replaced with either a $\frac{1}{16}$in or $\frac{1}{8}$in diameter steel ball. It gives direct readings on Rockwell C and B scales, whilst, if required, the F, G, E, K and A scales are obtainable. The tester is designed for the application of loads of up to 150kg and the loading is adjustable by means of a handwheel.

The instrument incorporates a hydraulic pressure assembly consisting of a diaphragm unit filled with fluid and coupled to a finely calibrated dial pressure gauge, which, as can be seen in the illustration Fig. 16,

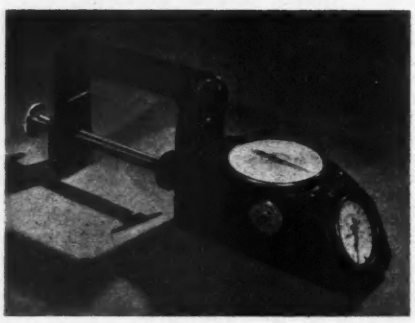


Fig. 16—Direct Reading Portable Hardness Tester—Tennant

is mounted on top of the body of the instrument. This hydraulic unit is so designed that it will not normally be subject to variations owing to changes in atmospheric conditions, but to ensure absolute accuracy a zeroing device is incorporated in the pressure gauge. The depth of the impression is measured by a lever mechanism coupled to a direct reading hardness recording dial on the end face of the instrument. This dial gauge is graduated in units of 0·002mm, or 1 point on the Rockwell hardness scale.

The standard clamp provided with the instrument is capable of holding test pieces up to 6in thick or 5in diameter or irregular shapes. A range of alternative clamping attachments is available.

When operating the instrument, with the test piece firmly clamped in position, a "minor" load is first applied by turning the small wheel on the left-hand side of the body. When the needle of the dial pressure gauge indicates that this load is reached the dial is put in the set position, and this is indicated by a secondary hand on the face of the pressure gauge operated by rotation of the dial bezel ring. By then turning a load application handwheel the "major" load is applied. This load is maintained for ten seconds and then released until the pressure gauge again indicates the original "minor" load position. The hardness of the specimen is shown as a direct reading on the recording dial gauge.

For research and laboratory work the firm makes another model of the "Indentometer," which is similar in appearance and operation, but has a hardness recording gauge graduated in divisions of 0·001mm, or 0·5 on the Rockwell scale. The maximum load which can be applied with this instrument is 45kg, the corresponding "minor" load being 3kg, and it gives direct readings of the N and T Rockwell hardness scales.

Taylor and Challen, Ltd.

One of the presses exhibited by Taylor and Challen, Ltd., Constitution Hill, Birmingham, is the high-speed double-roll feed machine of 20 tons capacity, illustrated in Fig. 17. This machine is shown performing blanking and piercing operations on strip copper and is provided with a coil carrier and

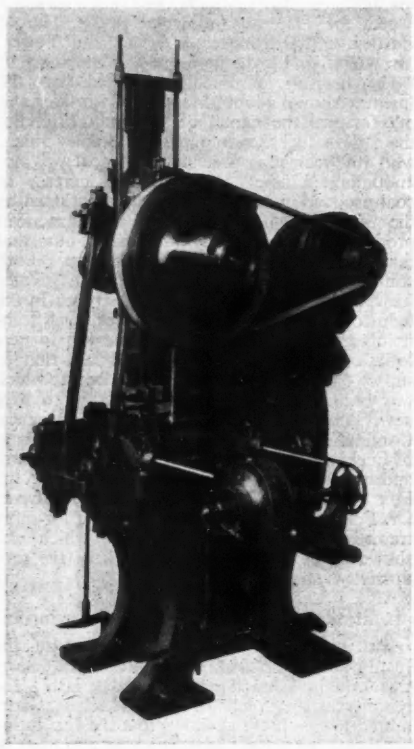


Fig. 17—20-ton Double-Roll Feed Press—Taylor and Challen

scrap winder. It has a small flywheel and is arranged to run at 250 r.p.m., being driven by a 3 h.p. motor. The feed mechanism of the machine gives, through a roller friction clutch, a travel which is variable up to 5¼in. Provision is made for the rolls automatically to release the strip when pilot punches are used in follow-on tools, and the feeding-in rolls can also be released by a pedal for inserting strip. When required, an automatic gauging and timing mechanism can be fitted, and this ensures that a newly inserted strip is fully fed from a predetermined position into the dies and that no "half-blank" is cut in the front edge of the strip.

A hot brass press on the stand has a long stroke and is designed for high-speed operation. This press is driven by a 15 h.p. motor and is geared to run at sixty strokes a minute. It is equipped with automatic vice, side and bottom movements and is intended for use with split dies. Toggle gear which operates the vice is worked by a cam on the crankshaft through links and levers. Additional levers formed on the toggle links of the vice action are engaged by rubbing pieces on the main slide to give a positive holding action to the vice, to prevent to the greatest possible extent the forming of a flash.

The side motions consist of slides on each side of the vice, having transverse movements operated by the main slide. As the press slide descends these enter each side of the die space, thus forming cores round which the pressed articles are extruded. The bottom motion is operated by links and levers from a crankpin on the end of the crankshaft to an eccentric shaft which operates a connecting-rod and slide working in a vertical position. Provision is made for fixing a punch in this slide. As the main slide descends the bottom motion slide ascends and enters the die space, thus forming a core round which the pressed articles are extruded.

The vice can be closed sufficiently by hand to hold the hot blank in position until the press is started, when the dies are closed and afterwards opened by power. Air equipment is fitted to provide control to the opening and closing of the vice and a foot valve controls the clutch mechanism. The equipment is interlocked to prevent the press being started before the vice is closed.

Roto-Finish, Ltd.

A medium-sized barrel finishing machine with a capacity of 13½ cubic feet is being shown for the first time by Roto-Finish, Ltd., 39, Park Street, London, W.1, a firm which specialises in mechanical finishing and deburring supplies and equipment. This machine is designed for deburring, uniform radiusing, descaling, polishing and honing of components in all metals and alloys.

As can be seen from the photograph, Fig.

Fig. 18—Barrel Finishing Machine—Roto-Finish

18, the machine has an octagon-shaped barrel, which is fabricated from sheet steel and lined with abrasion-resistant rubber. The main frame is of all-welded steel construction and in it the barrel shaft is carried on self-aligning ball bearings mounted in plummer blocks. A 2 h.p. motor mounted in the frame drives a reduction gearbox through vee ropes, and the drive from this gearbox to the barrel shaft is by means of sprockets and roller chains. The controls incorporate a waterproof reversing switch with thermal overload protection, and there is a built-in automatic timer, a heavy-duty magnetic

reversing starter, inching control and a magnetic shoe brake.

The photograph we reproduce shows the barrel being flushed out into a tank mounted on wheels whereby it can be easily pushed in and out of the base of the machine. The barrel door is held by quick-acting spring-loaded cam locks, which are adjustable for pressure.

R. H. CORBETT AND CO., LTD.

A useful fork-lift truck, particularly intended for establishments where the volume of goods handled is not very large and the distance they have to be moved is not very great, is now being made by R. H. Corbett and Co., Ltd., Hydrum Works, Burgess Hill, Sussex. This machine, known as the "Hydruped," is capable of handling a maximum weight of 1000 lb and is made to lift to a standard height of 6ft, although, if required, it can be made for lifts up to 10ft.

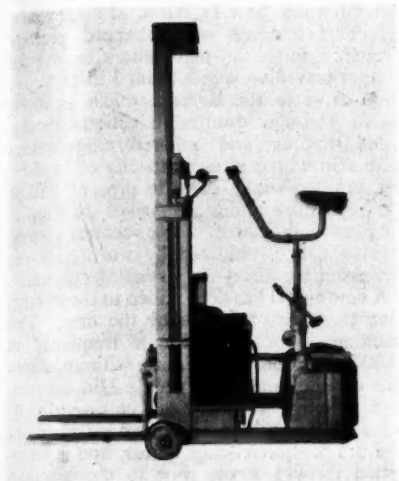


Fig. 19—Pedal-Propelled Fork-Lift Truck—Corbett

The forks are operated by a battery-operated hydraulic system consisting of a hydraulic pump driven by a 12V electric motor. A point of special interest in the design of the machine is the unconventional method of propulsion, which is by means of pedals and gearing connected to the rear wheel by a chain drive. As can be seen from the illustration of the machine in Fig. 19, the operator sits upon a bicycle type saddle and steers the machine by means of a bar in front of him whilst he turns the pedals. Actual steering calls for no manual effort, as it is operated by electro-hydraulic means, hydraulic power being made available through depression of a micro switch on the handlebars. The overall length of a machine fitted with 30in forks is 6ft 6in and the turning radius is only 3ft 7in.

Fig. 20—Stacking Machine—Corbett

The new "Hydrum" high stacking machine shown in Fig. 20 has been designed for use in narrow gangways and for handling loads up to 3 cwt. The elevating unit incorporates a platform for the operator of the machine so that he can be raised together with the load. Goods can be stacked into shelves up to 12ft high with this machine. It is driven by batteries through an electro-hydraulic pump unit.

ENGLISH STEEL CORPORATION, LTD.

Some months ago what is stated to be the largest steel ingot ever cast in the Commonwealth was made in Sheffield by the English Steel Corporation, Ltd. The actual ingot weighed 270 tons, and was 26ft long by 10ft 4in across its largest octagon section.

A full-sized model of this ingot is exhibited to give an impression of its size. It was the first of a number of similar ingots which are to be forged under a 7000-ton electro-hydraulic press into high-pressure, one-piece boiler drums, 42ft long and 6ft 2¼in outside diameter, for new power stations being built for the British Electricity Authority by Clarke Chapman and Co., Ltd. Steel for the ingot was provided by four acid open-hearth Siemens furnaces, and apart from the high technical skill required in the casting of such an ingot, its lifting and transport set many problems. Two overhead cranes, coupled by a specially constructed lifting beam, were used and to ensure co-ordination of lifting and teamwork in other phases of the operations, several rehearsals were held, a 210 ton ingot being used for the purpose. When stripped from its mould the ingot was loaded on to a 300-ton, twenty-four-wheeled railway bogie, specially built for the internal transport of large ingots, forgings and castings, and was taken to another department of the works for further processing.

Highly finished crankshafts and jet engine discs made from the firm's alloy steels are also shown as well as a display of coil and laminated springs and torsion bars. Of interest to engine builders are the crankshafts forged by the continuous grain flow process. These shafts embody the advantages of a drop forging, but can be made in sizes that are beyond the capacity of drop forges.

The products of the corporation's works at Openshaw, Manchester, are shown in displays of engineers' cutting tools, and include the new "Easicut Blue" drills, ground thread taps and end mills; tool steels, files, hacksaws and permanent magnets.

DALE ELECTRIC (YORKSHIRE), LTD.

A new diesel generator now being made by Dale Electric (Yorkshire), Ltd., Filey, is illustrated in Fig. 21. In this unit, which is available for 3kVA or 6kVA, the engine and alternator are mounted on a common bedplate of rolled channels and the alternator can, when required, be removed without much disturbance of other components. This alternator is a self-excited, self-regulating unit with starting windings and a battery-charging circuit. The set is normally rated at 240V a.c., single phase, 50 c/s, but it can also be supplied to any other standard voltage at 50 or 60 c/s.

A switchboard supported by anti-vibration mountings on top of the generator incorporates the equipment for the automatic operation of the plant. All the relays in the cabinet are mounted to facilitate easy servicing and should the set fail to start an automatic control prevents the batteries becoming completely exhausted. One solenoid fitted to the engine operates the decompressor and fuel control and another solenoid ensures that the engine is running at full speed before being loaded.

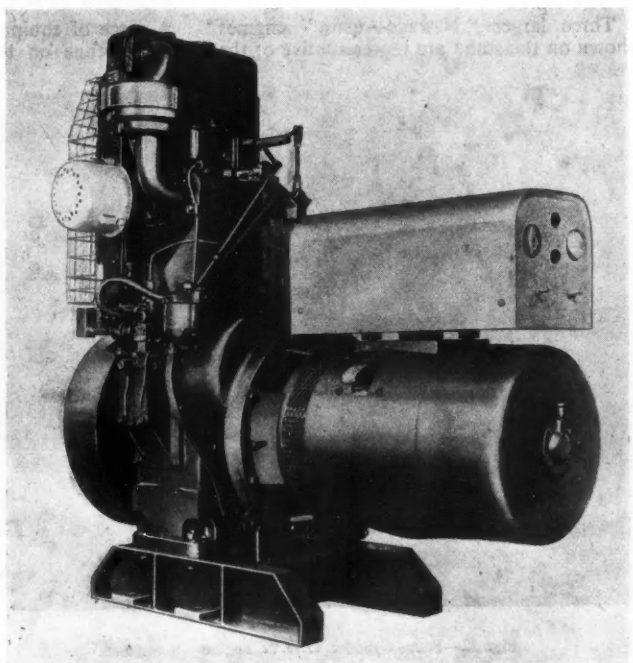


Fig. 21—Diesel-Electric Generating Set—Dale

POLYGRAM CASTING COMPANY, LTD.

An interesting demonstration has been arranged for the stand of the Polygram Casting Company, Ltd., Power Road, Gunnersbury, London, W.4, to show the shell moulding process in operation using the firm's automatic shell moulding machine. This machine was described and illustrated in THE ENGINEER of January 16, 1953, and it is designed to produce the shells of two half-moulds every minute or the equivalent of sixty complete moulds an hour.

In the machine cycle a pattern plate is invested with the sand/resin mixture at the first station and the plate, together with the shell so formed, passes through a curing

oven in three intermediate stages. At the end of the curing period the plate and shell are indexed back to the first station where the shell is removed and the plate reinvested ready for the next cycle. Thus, whilst three shells are passing through the oven an operator at the fourth station is engaged in removing a finished shell and reinvesting its pattern plate. The ease with which shell moulds can be handled is demonstrated by the use of female labour to operate and serve the machine.

Demonstrations have been arranged to show the accuracy and finish obtainable with shell moulding, and how the strength of shell moulds makes it possible to reduce the use of cores in certain cases.

Newage (Manchester), Ltd.

Industrial engines which are made to specific requirements by Newage (Manchester), Ltd., are shown in a variety of applications on that firm's stand at Castle Bromwich. A new engine of interest to be seen is the industrial model of the "Austin 7" engine, which is now in production, and can be adapted in various ways for individual commercial requirements. One arrangement of this new four-cylinder 800 c.c., o.h.v. engine can be seen in Fig. 22. It has a bore of 2·28in by 3in stroke and develops 30 b.h.p. at 4800 r.p.m., the maximum torque being 40 lb/ft at 2400 r.p.m.

Three larger "Newage-Austin" engines shown on the stand are representative of the

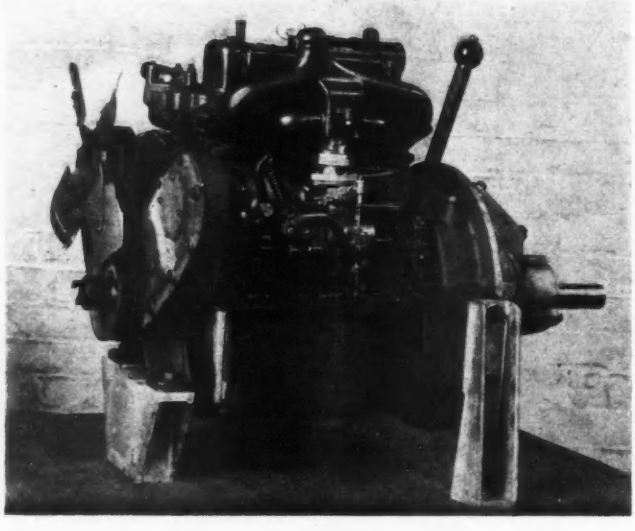


Fig. 22—Four-Cylinder O.H.V. Engine—Newage

design widely used in industry and agriculture, and together with them is one of the new "Stamford" lightweight alternators developed by the firm.

Hall and Hall, Ltd.

Packings, jointings and gaskets for use in various industries are made by Hall and Hall, Ltd., Oldfield Works, Hampton, Middlesex, and in a selection of these the firm is showing a new fluid seal which it has introduced to overcome certain disadvantages of "U" type packing rings.

This "Hallprene" seal is made of synthetic rubber impregnated fabric in the form of a "U" ring, and filled with a soft and resilient synthetic rubber, the whole being bonded together, as can be seen in Fig. 23. The composition is impervious to the action of hydraulic fluids up to a temperature of 250 deg. Fah. When the ring is in use the pressure of the fluid deforms the soft synthetic rubber and causes the sealing surface of the impregnated fabric side walls to expand. The seal is made with slightly divergent walls, and, as the filling is resilient, the walls of the ring do not tend to collapse. Once the ring is put under pressure the pressure is

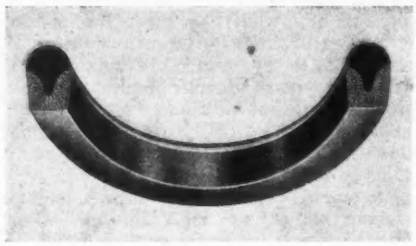


Fig. 23—Fluid Seal—Hall

maintained to retain the sealing effect even should the fluid pressure fall to nil.

The sealing lips of the "U" ring are protected against damage by their being bonded to the resilient filling. The curved exposed surface of the filling, which is presented to the pressure side of the joint, helps to ensure that when it is used in a stuffing-box the fluid pressure acts over the whole of the exposed surface.

John Blackwood Hodge and Co., Ltd.

A piece of equipment being exhibited for the first time on the stand of Blackwood Hodge and Co., Ltd., 11, Berkeley Street, London, W.1, is a "Euclid" bottom dump wagon designed for a struck capacity of 13 cubic yards or a heaped load of just over 15 cubic yards.

The tractor used with this unit is fitted with a Leyland engine rated at 154 h.p. at 2000 r.p.m., driving a five-speed gearbox through an 18in single-plate Borg and Beck clutch. The trailer is mainly of welded steel construction having a hopper with $\frac{5}{16}$in thick side plates and $\frac{3}{8}$in front and rear plates with stiffening channel members and reinforced round the edges. A centre partition of welded box construction is bolted through the side plates to the outer stiffening channels. The axle frame consists of triangular box sections reinforced by a transverse brace plate and welded to the hopper sides and rear plates and carrying cast steel axle brackets.

The hopper doors are opened and closed by an air-controlled mechanism through cables. Through an air control valve on the steering column the doors are opened by releasing a cable drum lock. The doors are closed by engaging a winding mechanism on the rear trailer wheel which is automatically disengaged when the doors are fully closed.

When empty the tractor and trailer together weigh just under 16 tons, whilst with a full payload the combined weight is nearly 34 tons. In the loaded condition the weight on the front axle is 12,200 lb, on the driving axle 31,600 lb, and on the trailer axle 32, 000 lb.

Other equipment on this firm's stand includes a "Carlisle" grader and angle-dozing equipment, and a "Euclid" tractor and scraper unit.

C. H. Johnson (Machinery), Ltd.

A 1 cubic yard capacity dumper now being made by C. H. Johnson (Machinery), Ltd., of Stockport, is exhibited with examples of the pumps, rammers, conveyors, &c., manufactured by the company for builders, constructional engineers and public works contractors.

The dumper is largely of fabricated steel construction and is propelled by a Petter twin-cylinder oil engine rated at 6 b.h.p. at 1000 r.p.m. and 12 b.h.p. at 1800 r.p.m. This engine drives a three-speed gearbox through a single dry-plate clutch to give the dumper travelling speeds from 3 to 11 m.p.h. Final drive to the large rear axle is transmitted through double reduction gearing. A self-tipping and self-returning welded plate skip with a struck capacity of 16 cubic feet, is fitted with shelves to prevent spillage during loading, and these shelves are adapted to form mudguards. The centre pivoted steering axle is actuated by worm and peg gear from the heavy-duty steering column.

A new model has been added to the internal concrete vibrators made by the firm. This machine is designed for a frequency of 10,000 vibrations per minute, with an amplitude of $\frac{1}{16}$in, and has a needle $2\frac{3}{4}$in diameter by $9\frac{1}{2}$in long. Its drive can be provided by either a 4 h.p. Villiers air-cooled petrol engine or a 3 h.p. squirrel-cage motor, and is transmitted through a vee rope to the jackshaft pulley. Flexible shafts can be assembled to give an operational length of up to 36ft to the vibrator. The vibrating unit consists of an out-of-balance rotor mounted in ball and roller bearings, housed in a one-piece casing, the tip being formed from the tube. If necessary, the needle can be immersed in the concrete to the full length of the flexible shaft.

Taylor Woodrow (Building Exports), Ltd.

Taylor Woodrow (Building Exports), Ltd., 41, Welbeck Street, London, W.1, is exhibiting for the first time at the B.I.F. this year, with a stand at Earls Court, where models and illustrations of the "Arcon" prefabricated structures designed and marketed by the firm may be seen. However, to give visitors a first-hand impression of these products, the firm has arranged a car service between Earls Court and its development site at Southall, where the prototypes have been erected. The range of "Arcon" structures has been considerably increased in recent months by the addition of seven new developments in addition to the tropical roof, storage building and purlin roof which have been in use for some time.

Generally the "Arcon" structures consist of welded tubular steel trusses supported on steel tubes or rolled steel joists as stanchions, with tubular purlin members carrying corrugated asbestos sheet roofing, and tubular steel or wire rope ties for wind bracing. The details of cladding, eaves extensions, windows, and so on, can be arranged to suit the requirements of any one case. Thus, the dual merits of standardisation of components and flexibility in the layout of the finished structures to suit different climates and uses are aimed at in the conception of these buildings. A 40in module is used as a standard dimension and the steelwork is designed according to B.S.S. 449, although different wind loadings or snow loadings, for instance, may be taken for structures

Fig. 24—Construction of "Arcon" Storage Building—Taylor Woodrow

intended for different parts of the world, as local conditions dictate; generally, the weight of steelwork is between 4 and 5 lb per square foot of covered area. As with other systems of prefabricated construction intended for use in undeveloped countries, ease of transport and erection have received consideration in the design of these buildings.

The steelwork for a 50ft span "Arcon" storage building is shown under construction in Fig. 24. This illustration gives a good idea of the tubular steel design; it shows a dockside shed at Fremantle Harbour in Western Australia. The storage building may have a span of 50ft or of 33ft 4in, and may consist of any number of 16ft 8in bays, with stanchion heights of 10ft 6in, 14ft 6in or 20ft 6in. For smaller buildings, the general purpose "Arcon" roof may be used, with spans of 21ft 8in, 26ft 8in or 35ft, lengths of bay of 10ft or 13ft 4in, and stanchion heights of 9ft, 12ft or 14ft 6in.

Other designs of the "Arcon" range include a 21ft span, three-pin braced portal frame, for use with light foundations where light wind loading is encountered. This structure can cover 42ft with side extensions and the size of bays in the longitudinal direction is 12ft. The north light or "sawtooth" building shown in Fig. 25 is an innovation for prefabricated structures. It is designed along similar lines to the other buildings, with welded tubular steel structural members and corrugated asbestos sheet walling. Its minimum size is 50ft by 50ft, which may be increased either at the back or the sides by the addition of standard sections of 50ft by 16ft 8in. There is a choice of heights of 14ft 6in and 20ft 6in.

Another recent development of the "Arcon" group is a structural panel for cladding large buildings, which consists of corrugated aluminium alloy sheets (stainless steel may also be used), held by bolts in a framing of extruded sections.

All Purpose Building Company, Ltd.

An illustration on this page, Fig. 26, shows the construction of one of the "Apee" range of buildings made by the All Purpose Building Company, Ltd., Sudbury, Suffolk; this firm is exhibiting at the B.I.F. for the first time. The "Apee" buildings are manufactured in three standard designs of 40ft, 50ft and 60ft span, of which the 40ft span model is exhibited, both at Earls Court and Castle Bromwich.

The buildings are all of lattice portal frame design, manufactured on a unit construction basis; the standard building is 100ft long (eight bays of 12ft 6in), but buildings of different lengths can be made up of the standard 12ft 6in multiples, and spans may be erected side by side. The maker states that there is no single part in the design which cannot be lifted by two men with ease, thus facilitating erection or transport in undeveloped zones. A complete erection kit can be supplied by the firm, containing adequate plant and equipment to erect any of these structures. The kit includes a small prefabricated erection mast, chain blocks, guide ropes, spanners and other requisite hand tools. The steel frame of the buildings may be clad with either asbestos or aluminium corrugated sheeting or local walling material may be used between the stanchions.

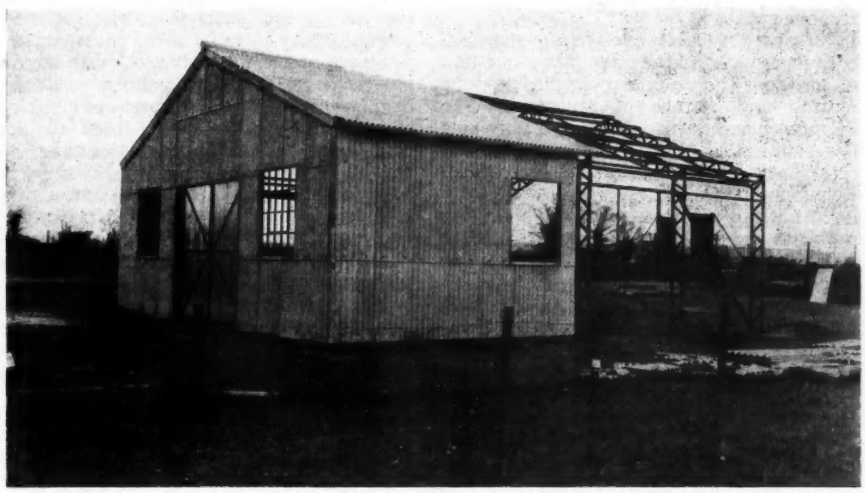


Fig. 26—Portable Frame Building—All-Purpose Building Co.

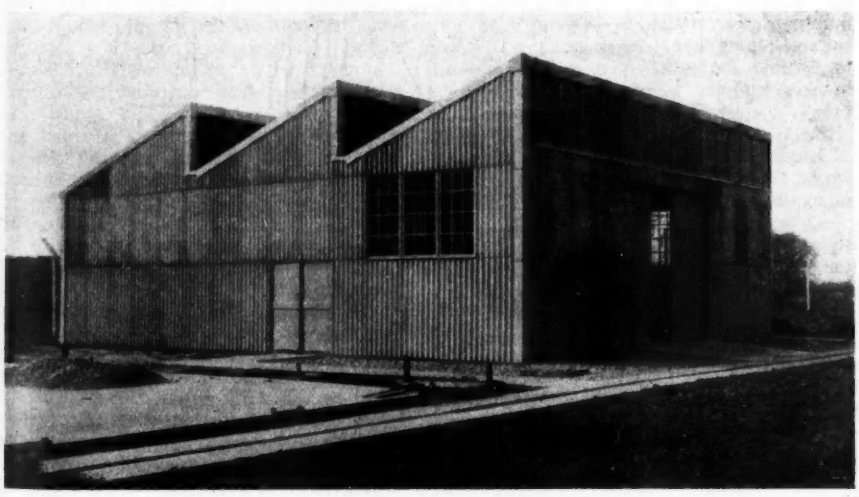


Fig. 25—"Arcon" North Light Building—Taylor Woodrow

(To be continued)

Machine Tool Firm's Centenary.—This year the firm of Craven Brothers (Manchester), Ltd., Vauxhall Works, Reddish, celebrates its centenary. It was founded in 1853 by two brothers, Greenwood Craven and William Craven, who were born in Bradford, Yorkshire, and who, in their youth, moved with their parents to Manchester. Greenwood Craven, the elder of the two, served an apprenticeship with Sharp, Roberts and Co., whilst William received much of his early engineering training by working for John George Bodmer, the inventor, at the Cambridge Street Mills, Manchester. The latest issue of *The Craven Machine Tool Gazette*, a quarterly journal published by the present company, begins an interesting and informative account of the development of the firm, recording the progress which it has made over the first century of its existence. The firm's first home was at Dawson Croft Mill, Salford, and there, in July, 1853, the Craven Brothers completed their first order, which was for a planing machine. A third and younger brother, John Craven, joined the firm in 1858. The Vauxhall Works at Reddish were built in 1900, and the company was constituted in its present form in 1928.

American Industry and the Problem of Materials Handling

THE JAMES CLAYTON LECTURE

By JAMES R. BRIGHT, M.S., M.A.S.M.E.*

No. II—(*Concluded from page 596, April 24th*)

Below we print some extracts from the James Clayton Lecture, presented before the Institution of Mechanical Engineers on Friday, April 17th. The aims of the lecture were to clarify the major objectives of a materials handling programme; to show how progressive companies are organising for materials handling; to describe the scope of the good materials handling programme; the kind of individuals to be placed in charge; the authority and responsibilities to be delegated to them, and the ways in which these activities co-ordinate with, and contribute to, other aspects of the plant. Techniques of analysing materials handling problems and the characteristics of basic materials handling devices were presented briefly. Finally, some fifteen significant trends in American materials handling practice were discussed and briefly illustrated by case examples.

Methods of Solving Materials Handling Problems

A Philosophy for Analysis.—In spite of the thousands of articles that have been written on the subject of materials handling, amazingly little information is available on how to approach the materials handling problem. "Old-timers" seem to rely on experience and rules of thumb, or solutions of similar problems in the past. On the other hand, some enormously elaborate classification lists, charts and similar things have been recommended.

Perhaps a suitable engineering approach is to regard materials handling as a question of methods improvement applied to the moving and storage of materials. The average engineer will find trouble only at a few points :—

(*a*) Lack of familiarity with analytical techniques in this field.

(*b*) Lack of performance data, application problems and operating characteristics of the 300–400 materials handling devices.

(*c*) Lack of knowledge about the materials themselves, particularly in handling bulk materials.

One gross error is often committed by the inexperienced. It is the assumption that mere application of a piece of mechanised equipment automatically solves a handling situation. Therefore they concentrate on the selection of equipment and ignore the factors that make up the materials handling problem. This is a pitfall that should be avoided. A materials handling problem is like any other engineering problem : there are known and unknown factors. An answer is evolved by establishing quantitative and other data for each factor (through measure, test or assumption) and relating them to each other. In the materials handling situation this answer is the equipment. The factors are the material, its required movements and the operational conditions. Thus, one might call the "materials handling equation" :—What+where+when=how.

"What" is the material, its shape, condition and volume. "Where" includes the origin of the movement, the destination of the movement, the restrictions on the path, and similar factors. "When" includes the timing of receipt, delivery and various inter-movement timing requirements. Adding these, defines "How."

"How" includes the containers, if any, and the type of handling device. "How" is the result of the materials handling study. One should not start with the equipment and attempt to make it fit into a particular handling situation. This is the basic error of the beginner.

The "What" in Materials Handling.—The engineer's first concern should be to study the material for it is the heart of the problem.

(*a*) *Form.*—Is the material liquid, solid, or a gas ? If it is a solid, could it be received best as a powder, lumpy or granular material ? If in a fixed shape, such as sheet or rods, should this be changed to coils, small pieces, or some other form ?

The primary material should be considered, not the secondary material. The primary material is the material actually wanted. The secondary material is the container, the wrapping or the waste material that accompanies the primary item. Many materials handling problems have been reduced to utmost simplicity by going back to this fundamental point. For instance, one plant used to receive hydrochloric acid in carboys. These carboys had to be boxed and crated, and thus each consisted of a fragile unit that had to be unloaded, stored and moved around the plant with the greatest care and with corresponding expense. Investigation proved that it was not necessary to handle this material as fragile, solid object (that is, a liquid in bottle). After all, the liquid was the primary item, the bottle was secondary.

The materials handling engineer asked : why not handle this material in bulk ? Investigation showed by installing tanks on the outside of the building and arranging suitable piping, handling would be much quicker, simpler and safer, as well as cheaper. A great deal of handling was eliminated and safety was much improved.

As a corollary, it should be realised that the container in which material is received is not necessarily a fixed thing. The container is entirely secondary. Fundamentally, the engineer is interested in the contents. Therefore, in any materials handling study, the contents rather than the container should be considered. Often the container can be modified, changed or dispensed with, to the simplification of the problem.

(*b*) *Special Nature.*—Thousands of materials have some peculiarity, some special factor that affects their handling. Glass is brittle ; paint pigments must not be contaminated by outside materials ; food products must be kept sanitary ; many chemicals have poisonous fumes or will react with various types of container materials. Textiles cannot be stored exposed to the weather, highly polished metal surfaces must not be scratched. These are a few of hundreds of restrictions that apply in varying degrees to different materials. Thus, the second point is to consider the nature of the material, and the possibility of changing any unusual properties of the material to facilitate use of a better materials handling system.

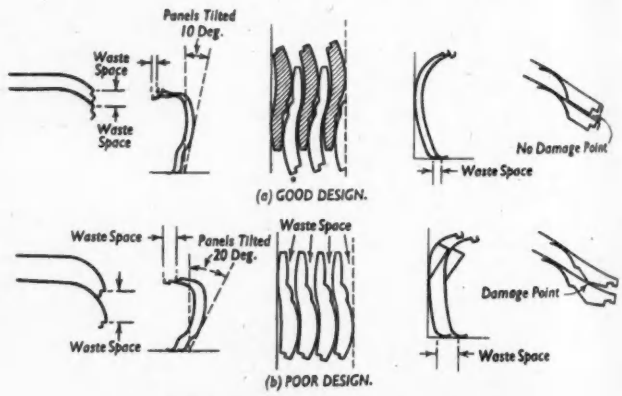
(*c*) *Shape.*—The shape should be investigated with a view to modifying it to simplify the handling. For instance, might it be easier to handle a material if it were received in sheets 4ft by 4ft instead of 4ft by 8ft ? Would it be better to receive the item as a bar 16ft long or as two bars 8ft long ? Indeed, it may well pay to have some processing done on the material before it is received at the plant to eliminate a troublesome handling problem and a cumbersome initial processing step. This has long been realised by design engineers, but often has been overlooked in the cost of materials handling.

A further extension of this idea is to consult with the design engineers with a view to modifying the original shape of the product. An example of this is in the automobile industry where the shape of body stampings, fender panels, and so on, is studied to provide for nesting them (Fig. 1). Some automobile companies make a point of reviewing every design in the materials handling department with a view to assuring a minimum handling problem and minimum delivery costs.

Other aspects of design should be considered, such as provisions for places to grab, lift and hold the material.

(*d*) *Size.*—Larger units mean fewer "handlings" per given volume. This is well worth exploring. Consider this example quoted by an oil-well equipment manufacturing company :—

"For years we received bar stock from our suppliers in lengths from 14ft to 19ft. You may ask me 'why ?' We don't know, we just got them that way. Through our processing, plant layout and purchasing, we began checking our beds for cutting equipment, our clearances for the railway, our purchasing with the suppliers with the thought in mind of increasing the bar lengths. After several weeks of negotiations with the steel mills we were able to increase the bar lengths. Instead of the 14ft to 19ft lengths,



By designing to facilitate nesting, tremendous savings can be made in dispatch and storage activities.

(Courtesy of Fisher Body Division, General Motors)

Fig. 1—Profiles of Stamped Metal Parts, Showing How Small Changes in Design Influence Proper Nesting

* Chief Editor of *Modern Materials Handling* (Boston, Mass.).

we were getting them from 32ft to 35ft in length. Now each bar has from one to two ends of unusable residue cut off and thrown away. Compare if you will the inspection costs of the bars of 32ft to 35ft length with those of 14ft to 19ft. Compare your locomotive crane time, your storage space, everything pertaining to your handling of those bars. The savings amounted to some 18,000 dollars per year in that one project alone."

(*e*) *Volume.*—The volume of material to be handled is the next major consideration. Many materials handling activities have a peak and the handling must provide for these peaks without having undue, expensive, wasted capacity during normal times. Therefore, a significant part of the analysis is to determine (i) the quantity ; (ii) the occurrence of peak loads ; (iii) their frequency and (iv) their duration.

The "When" in Materials Handling.—Closely associated with volume is the question of timing. Even though a material flow may be relatively uniform, there may be intervals at which materials must be received or delivered at an especially high rate. This should be taken into account. The possibilities of improving product quality, of reducing demurrage charges, of releasing common carriers more quickly, of gaining a sales advantage through faster delivery, should be explored. They often can be gained through faster handling systems.

The "Where" in Materials Handling.—Having determined what must be moved and how much must be moved, and when, the next question is : where shall it be moved ? An analysis of the material movement should cover the following :—

(*a*) Destination of material : to what point is the movement destined ? Is this truly the ultimate destination or only a temporary storage point ? If the latter, is it possible to eliminate this delay *en route* ? Is the destination fixed ? Does it change from time to time ? Would another handling system offer the flexibility to meet this ? Is there the possibility of a permanent relocation in the foreseeable future which might require a different handling system ? Each of these points must be checked.

(*b*) Next consider the origin of the movement. Is this fixed ? Is it likely to change in the future ? Is it desirable to change it ? Could it be changed now to shorten or simplify the materials handling movement ? Each of these questions may provide the key to a troublesome handling problem.

Do not overlook the fact that dispatch by common carrier may change. Thus material previously received at a railway wagon siding may be received by the motor lorry depot. This may completely change the material flow arrangement.

Within the plant, particularly in job-shop work where material movements initiate from numerous machines, the possibility that the sequence of manufacturing processes may be changed should be considered. The movement may be in a different location. Materials handling systems should be flexible enough to meet these changes economically.

(*c*) Restrictions on the path—too many materials handling movement analyses consider only the route that is followed at the time. The investigator is led by chart or procedure to study just an existing material flow path. This can be quite misleading ; rather, the limiting factors that restrict the possible paths over which material might move should be examined.

Consider, for instance, the plant that has just expanded by purchasing another industrial building lying perhaps a hundred yards away across a heavily travelled street. At first glance, one would think of surface transportation for moving materials from one building to another. While this may be an answer, it is not necessarily the best answer. A number of other possibilities can be investigated if the materials handling engineer does not limit his thinking to surface transportation.

It is conceivable that it might pay to excavate an underground passage and install belt conveyors, trolley conveyors, or roller conveyors for this movement. It is also possible that some sort of automatic overhead mono-rail system could be successfully employed. Either one of these plans would eliminate interference with surface traffic and provide complete protection for the materials handling movement.

Again, consider the problem of a paint factory which must move paint pigments from the point of receipt on the first floor to large storage hoppers on, say, the fifth floor. The conventional approach would be merely to examine possible paths of flow over existing floors, up existing elevators and so on. This viewpoint is too narrow. Rather, the engineer should block off the limiting factors and then consider what handling system might fit into the remaining conditions. In this case it is obvious that to use existing facilities an extremely tortuous path must be followed. Many handling transfers must take place. Elevators are likely to delay, and be delayed by, this movement of material. Yet there is no reason why an elevator system must be used.

It might pay, for instance, to mount a hoist, with "clam-shell" bucket, out of a fifth-floor opening and lift the material directly from the exterior of the building into the fifth floor. Special containers, designed for fork-truck handling and having hopper discharge bottoms, might be brought up outside the building by hoist to monorails or by trolley conveyor. Another approach, and one that was actually used, might be to use a special kind of conveyor—the zipper belt conveyor—which is one of the two "conveyorised" techniques for moving bulk materials through an extremely small and tortuous path (the other is a pneumatic system). The zipper belt can wind and twist through a number of planes and in any direction, yet the equipment occupies little space. This conveyor was mounted inside the building and easily negotiated narrow passageways, and so on, yet provided continuous flow delivery. Here is a clear-cut case for not allowing one's thinking to be confined by the obvious handling methods.

Before concluding the "What" and the "Where" analysis, the permanency of the solution should be weighed. Is it possible, or likely, that requirements of the layout or the production system will be changed either in volume or in timing ? Business conditions, the sales trend for the particular items concerned, the possibility of technological advances, the possibility of model changes or process improvements, each could modify the materials handling requirements. They should be considered before the analysis of materials handling is complete.

A second consideration is operational requirements of materials handling systems. What does management want ?

(*a*) Does it want maximum production without regard to costs ?

(*b*) Does it want an absolute guarantee against any delay in production because of "down time" of the materials handling system ? Must the system offer unlimited flexibility ?

(*c*) Does it wish to have unlimited expansion or fixed capacity increases in the system ?

(*d*) What is the anticipated life of this particular materials handling project ?

These answers should be settled before the analysis is considered to be complete. Indeed, many a headache has occurred because the points were not thought of, or if they were, were not settled. Equipment to solve materials handling problems is like any other equipment : some courses are "temporary," some are "semi-permanent," and some are "lifetime" solutions to the problems. Management requirements may vary widely ; therefore, they should be considered before a solution is developed.

Equipment.—This is the "solution" of the materials handling equation. It is mandatory that the materials handling engineer be familiar with materials handling equipment. Merely by deciding on continuous flow rather than intermittent flow, the layout concept, as well as plant operations, may be changed completely.

Characteristics of Major Materials Handling Systems.—There are upward of 300 different kinds of materials handling equipment, but to bring order out of chaos it is well to consider the fundamental nature of three basic groups of equipment. The remarks that follow are intended to convey a general understanding of the basic characteristics of each group. Not all the advantages mentioned apply to every kind of equipment in this group ; and similarly, limitations mentioned often do not apply to a given piece of equipment in that group. But, for general understanding, it is believed these remarks will be of some help :—

Class (1) *: Vehicles.*—The great advantage of vehicles such as fork-trucks, platform-trucks, straddle-carriers, mobile cranes, industrial tractors, and non-powered two and four-wheeled hand trucks, is their flexibility. Within the limits of capacity, this equipment is completely flexible as to operating speed, location and paths. It is well adapted to dealing with a variety of objects. Hence, it is useful wherever a variety of handling situations is encountered during the course of the day. Since the investment is comparatively low, it is applicable to many situations. Thus, its flexibility as to use, its versatility as to materials handled, and its comparatively low cost, adapt it to a countless variety of intermittent, random operations that characterise so many handling situations in medium and small manufacturing plants and in the distribution industries.

Class (2) *: Conveyors.*—The conveyor is unmatched for low-cost handling where the volume and other conditions justify continuous flow (and, under some conditions, intermittent flow). In addition, the conveyor provides a precise timing of movement that permits many other production gains. It can assist in obtaining constant rates of flow ; it can be used to control and activate production machines. Often it can be constructed to assist in performing the production operation while in transit (for example, dipping, drying, heat treating, mixing, &c.). It eliminates much possibility of error and other human failings. In general, its path is fixed and is not modified as easily as is a vehicle's path. Usually conveyors are designed to handle a given item. Thus, they lack the versatility of other handling systems. However, it is possible to provide considerable flexibility in speed of movement and timing.

Class (3) *: Overhead Equipment.*—Overhead handling systems have numerous outstanding advantages :—

(*a*) They take up no floor space.

(*b*) They provide for maximum use of the space in moving and storing materials.

(*c*) They are undoubtedly the most versatile equipment for dealing with a wide variety of sizes and shapes of materials.

(*d*) They provide unmatched flexibility as to path.

(*e*) They provide the most complete cover of the area which they serve.

(*f*) They can handle heavier objects than can other classes of equipment.

Usually overhead systems are limited to an area. Sometimes two men are required—one on the machine and one on the ground as a "rigger." However, some amazingly ingenious attachments have eliminated much of this ground-crew requirement.

Techniques for Analysing Problems.—Basically, materials handling improvements are made through methods studies. The following are the techniques usually used :—

Flow Charts.—Flow charts (sometimes called flow process charts) are an extremely useful device for analysing the movement of an item of material through all or part of the manufacturing process. Since these charts are part of a mechanical engineer's background, and have been thoroughly covered in literature, there is no need to dwell on their usage. However, the flow chart does not in itself solve a materials handling problem. It merely presents the arrangement of facilities and the sequence of operations so clearly that the investigator can reach a better solution without too much difficulty. It by no means presents all possible alternatives. But it does give the investigator a starting point.

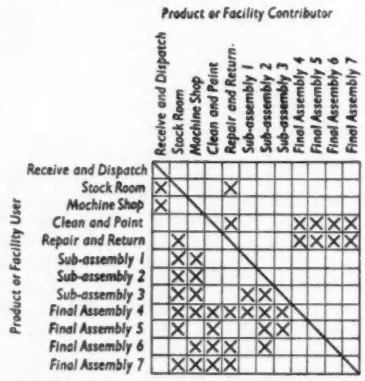
(*a*) *Flow Diagram.*—Like the flow process chart, this device is not new. It is a simple plan view of the physical materials handling activity. Usually it is used to supplement the flow process chart. It is valuable because it helps one to visualise the special relations of the materials movement, and it often suggests logical rearrangements of facilities to simplify the materials handling problem. The flow chart and the flow diagram form an excellent combination for clearly revealing a current movement problem and disclosing the weak spots. Like the flow chart, its use is well covered in the literature.

(*b*) *Travel Charts.*—A lesser known but extremely excellent device for investigating complex material flow patterns, is the travel chart developed by D. C. Cameron. It is a little-known technique but it deserves much wider recognition for it is perhaps the only quantitative, yet simple, device for exploring complex inter-departmental or inter-building material movement. In other words, it is one of the few ways to study an entire material flow picture, not just the route of one single item.

The conventional method of analysing material flow is to show route lines (on a layout blueprint) connecting the areas through which material passes. As the number of material items increases and the directions of travel multiply, such a chart eventually becomes a maze of lines, which are meaningless except to the person who made the chart.

The idea of the travel chart is to bring order out of this chaos so that the user may evaluate movement relations between areas. Roughly it follows the mileage charts found on the back of service station road maps in the United States. To make a travel chart in its simplest form, such as is shown in Fig. 2, the manufacturing areas are posted according to buildings or to adjacent departments along the horizontal axis. Then the same areas, in exactly the same order, are posted along the vertical axis. The areas listed on the horizontal axis are regarded as areas supplying or contributing material to other areas. The areas on the vertical axis are regarded as receivers or users of material. By putting X's or ticks in the appropriate squares, which departments are contributing materials to a given area can quickly be seen, or conversely, which areas are sending material to a given area. Very quickly, some logical rearrangements suggest themselves to minimise the overall movement of materials between areas. These areas can be made as large or small as wished, so that the travel chart can be used to analyse an enormous plant with many buildings, a single building, or even a single department.

An obvious refinement of the travel chart is to put quantitative figures in terms of volume or weight, or even number of units, standard containers, truck loads, and so on, instead of X's in the appropriate squares. Thus, a quantitative picture, properly weighted, is quickly revealed. The investigator is now in a position to examine the location of the areas with respect to each other, so that those areas that contribute largely to a given area can be associated physically with that user. It is possible to shuffle and rearrange contributing and user areas so that materials move the minimum distances ; also so that, as far as possible, the material is used within the area in which it is produced.



The check marks indicate materials movement between the departments concerned. Eliminating a check means eliminating a movement between two areas. Location of the checks may suggest a rearrangement of areas to cut down movement requirements.

(Courtesy of *Modern Materials Handling*)

Fig. 2—Travel Chart

Many conclusions can be drawn from the travel charts :

(i) Where a supplier area contributes to a large number of user areas there are the makings of a very complex production control situation. The solution of the production control problem might lie in realignment of user areas, or in a simplification of design so that the products can be grouped into larger families.

(ii) Frequently the travel chart shows an array of products out of phase with engineering and sales operations. This may suggest complete rearrangement. For instance, a firm that has not had a layout study for several years should not be surprised to find that each of the product lines has been allowed to grow into a complex family of model numbers and forms. Such a complexity is not readily distinguished until the information shown by the travel chart is provided. Often these charts have a startling effect upon the management group.

The travel chart is unique in that it visualises the overall plant activity in terms of movement and kinds of thing moved. Ostensibly used for materials handling, it frequently results in the simplification of product lines, the rearrangement of manufacturing facilities, and the growth of long-range plans of much more systematic and orderly nature. It is a tool that deserves far more use in the future.

(*c*) *The Quantitative Flow Chart.*—A number of firms use material flow lines superimposed upon a simple layout of the plant facilities, to study the materials handling problem. The quantitative flow chart follows this same technique, except that the material flow lines are given a width (or sometimes colour) proportional to the volume or number of units moved over that path. Thus, some striking deficiencies in arrangement of facilities become apparent. It also points out clearly the areas in which the most effort should be concentrated on materials handling. It is somewhat cumbersome where many items must be followed.

(*d*) *Work Simplification.*—Work simplification is the well-known technique widely used in every sort of analysis of engineering and activity. It consists essentially of studying the operation through a flow chart, flow diagram, or simple listing, and then challenging each step to see if it can be combined, simplified, eliminated, and so on. This is a standard technique, well publicised and known to most engineers.

Work simplification is extremely valuable in regard to materials handling when taught to foremen. Where these foremen have been encouraged to apply work simplification to their own relatively simple departmental materials handling activities, some amazing savings have resulted. For instance, a large corporation set up a programme to teach work simplification to every foreman in the 8000-man plant. The result was a saving of 250,000 dollars a year !

Only two men direct this programme. They do not "do" work simplification, they teach it. Hundreds of simple materials handling improvements have been made solely because dozens of foremen and supervisors have been put through an organised work simplification programme. In one case the unloading of a box car of rock salt was reduced from thirty-two man-hours to four and a half man-hours, simply by introducing a tractor shovel in place of hand labour. This is typical of dozens of materials handling improvements that a work simplification programme can bring.

It cannot be urged too strongly that every plant should put all of its supervisory people, down to and including foremen, through a work simplification training programme. This is essential if it is desired to achieve widespread consciousness and improvement of materials handling.

(*e*) *Methods Time Measurement.*—Time study techniques for analysing a materials handling activity are useful but limited. Unfortunately, an operation that is not being performed cannot be time studied. Therefore, there is no possibility of synthesis and pre-deduction. Methods time measurement was developed to solve this problem. It has been applied with great success to many materials handling activities.

The technique is adequately described in the literature. In brief, it consists of developing a standard performance time for each type of human motion. Then, merely by visualising a given operation and computing the standard times for each basic move, a "synthetic time" is arrived at, which gives a fair approximation of the situation. Thus, the investigator can compare as many methods as he wishes without having to put them into practice. It is a good technique for studying materials handling activities that are largely concerned with an individual who is moving things within a few feet of his work place.

(*f*) *Standard Performance Times for Equipment.*—Although not yet completely appre-

ciated, there is undoubtedly a need for similar standard performance times, particularly for fork-trucks. If, for instance, the time required to position forks in a pallet, the time to lift a load to running height, the time to accelerate to top speed, the average speed (feet per minute) in the average aisle, the time to turn, to manœuvre, to stack, and so on, were known, a fork-truck operation could easily be synthesised. Thus, with nothing more than a layout, a materials handling activity could be studied and different ways of doing the job compared.

There is, in the United States, no collection of these standard performance times as yet. However, a few companies have standard times for performing various materials handling functions derived by time studies, usually under their own specific conditions. One manufacturing company has recently developed a programme of preparing standard performance times for fork-trucks of 2000 lb, 4000 lb and 6000 lb capacity. Such data should be extremely useful, when available.

(*g*) "*Memomotion*" *Studies.*—Memomotion is nothing more than using the motion picture camera, operating at 100 frames per second, to photograph a materials handling activity. The aim is to study a given method in detail, so as to determine the time to perform basic elements of that activity, and thus arrive at a better method. It has had limited application in the field. It promises to be extremely useful where a materials handling activity is unusual and does not readily lend itself to synthesis by standard performance times, and also where labour crews are to be studied.

(*h*) *Standard Costs and Times.*—This is a procedure advocated by Colonel John Day, of Atlanta, and others. The concept, basically, is that every major materials handling activity in the plant be analysed and that a standard way of doing it be established. This standard way would include a procedure to be followed, the equipment required, the labour required, the standard allowable time, and the standard cost.

When a foreman was to perform a handling activity (for instance, unloading a box car) he would be given, by the scheduling department, a slip or instruction order indicating (i) the equipment, (ii) the personnel, (iii) the time, and (iv) the cost allowed. He would then have a specific target and management would have, in effect, a budgeted handling effort. The equipment would not stand idle, for it would be issued only against the standard orders. Furthermore, there would be no delays without explanations, nor would costs be allowed to get out of line without question.

The essence of this idea is to put materials handling on the same scheduled basis as every production operation in the plant. It makes materials handling subject to cost accounting controls and management scrutiny. With management scrutiny will come realisation of the savings possibilities. Enthusiastic support for better mechanisation should follow. This approach undoubtedly is one of the most important.

(*i*) *Plant Layout Techniques.*—Numerous types of template are being used for the physical job of shuffling and for studying the arrangement of machines, buildings and equipment. Doubtless the same devices are available in Britain.

A great many American firms are using extremely elaborate three-dimensional models. Each production tool is precisely modelled to some convenient scale. There are whole systems of these layout models and the manufacturers can supply exact replicas of as many as 6000 different kinds of tool, materials handling device, and standard item such as desks, chairs and so on.

Much more careful plant layout is achieved through these three-dimensional models. Many materials handling and plant layout men insist that, for their own purposes, a two-dimensional model is not necessary. However, for visualising a proposed layout to top management, a three-dimensional model is unsurpassed, they say. They feel that even though thousands of dollars are devoted to the models, the smaller percentages of error, the complete understanding between foremen, management and plant engineers, is worth may times the price.

Several other techniques, such as ratio delay studies, have been tried in the United States. As yet, they are not widely used. Doubtless they deserve more consideration and will receive it in the future.

[The latter part of the Lecture consisted of a review of significant trends in materials handling.]

The Institution of Naval Architects

ANNUAL SPRING MEETING

No. V—(*Continued from page 608, April 24th*)

ON Friday afternoon, March 27th, the meeting was held jointly with the Institute of Marine Engineers and the first paper presented was :

THE INSULATION OF A REFRIGERATED CARGO LINER

By K. C. Hales and J. D. Farmer, O.B.E.

SUMMARY

The authors review the various ways in which heat enters the cargo spaces of a refrigerated ship. This is discussed in relation to the total demand on the refrigerating machinery. The effect of various depths of insulation on the ship as a carrier of refrigerated cargo is examined. In particular, the interdependence of the power of the fans used to circulate air, and the standard of insulation, is illustrated for a particular example. The effect of insulation and fan power on cargo capacity and deadweight is shown. There is an optimum depth of insulation which will give a minimum of capacity lost to insulation and air ducts and a minimal penalty on deadweight.

The necessity, in some cases, to use insulation as a means of minimising condensation may mean a heavier insulation in places than would be required on grounds of temperature control. The effect on heat leakage of position in the ship and type of space is shown. The disposition of insulation as between overheading and deck in a locker is discussed. While no suitable insulating material of lower thermal conductivity than those in common use is at present available, the possible savings in capacity, should one become available, are indicated.

The calculated figures for heat leakage are minimal. In practice, margins for deficiencies in construction of insulation and performance of refrigerating machinery have to be allowed. The most common causes of excessive heat leakage are by exchange of air between inside and outside of the space and by air movement through the body of the insulation.

The methods of measuring the performance of the refrigerating equipment and insulation are discussed and results of measurements on a number of ships are quoted. These suggest that, in some cases, heat leakage can be far in excess of any estimate, but that in some ships at least agreement between measured and estimated heat leakage is reasonably good.

Discussion

Mr. H. R. Howells : My comments are intended to stress particular points and to draw attention to the fact that the bulk of the tables refer to a particular ship and will not be applicable to other ships unless they are very similar.

As regards the basic conductivity figure for insulating material used in all the calculations, 0·27 B.Th.U. per square foot per hour per degree Fahrenheit per inch, I stress the necessity for this margin. It is surprising how many people appear to be reluctant to make the necessary allowance.

I am pleased that the authors have included information on air circulation, for the effect of air circulation on the temperature range is often lost sight of.

The effect of position and shape of space on insulation, which includes a table showing the heat leakage, tied up with the volume, will apply only when all the spaces are refrigerated or when the adjacent spaces are refrigerated.

With regard to the results of performance measurements by inspection of the ships' logs, measurements and estimations of heat leakage, the estimated figures are probably good, but a number of factors come into the calculated figures which are not absolute fact. The operation of the plant is one which might cause a very large alteration in the figures.

Mr. John Baird : The paper is a good answer to questions raised by Mr. Basil Sanderson in his paper given last year. It follows up the Smith and Farmer 1934 paper in so far as the results of the researches contained in that paper are embodied in the investigation, and it also shows that the proposals made in the 1934 paper have been adopted in the modern cargo liner.

The paper deals with the present system of ship construction, and the problem is simply stated in the introduction, where it is said that " Short of actual improvements in insulating materials or methods of insulation, the less the space occupied by insulation the more will be needed by the cooling system." The paper indicates how an economic balance between these two factors can be attained.

As a result of the investigations now made, the present practice in thicknesses of insulation is justified, but attention has been drawn to outstanding weaknesses. Reference to Table V indicates that about 14 per cent of the heat leakage into cargo spaces is through hatch plugs and coamings. These hatch plugs and coamings occupy an area of roughly 12 per cent of the overheading, and yet the heat leakage from the overheading is very little more than from the hatch. This lends force to the statement that attention must be paid to the method of insulating hatches, both from the point of view of heat and air leakage. If the hatch could be designed with similar characteristics to those of the overhead deck, this problem might be solved, but it is complicated by stevedoring requirements and a balance will have to be struck. I agree with the authors that this problem must receive immediate attention.

The authors draw attention to the question of insulation on both sides of terminal bulkheads, and while their proposal to restrict the insulation on the non-stiffener side to circumferential ribands is probably worth while from a cost point of view, the necessary dunnaging which will be required on the bulkhead will prevent any addition to the capacity.

The authors suggest that any improvement in thermal conductivity of insulating materials can be utilised to provide increased capacity, and Table X indicates that the correct method is to reduce insulation thickness rather than to accept a decrease in heat leakage by retaining it.

Table XIV is not very comforting from the point of view of the practical application of theoretical considerations. A good deal of the discrepancy shown in the table can

be attributed to the quality of the insulation materials and the accuracy of its erection and fitting, and the authors' challenge to those concerned in the insulation of ships should be accepted. Methods of erecting and fitting insulation have improved considerably during the last decade, and I expect that in future the practical results should bear a closer relationship to the estimated conditions.

Mr. G. Laing : The authors mention the two materials usually employed, glass fibre and granulated cork, and as far as can be ascertained from independent sources the former material has a thermal conductivity value of 0·22/3 and the latter 0·29/31. These figures are obtained under ideal conditions and a factor of 15 to 20 per cent should be added to give a practical figure. This makes the figure of 0·27 suitable for glass fibre calculations, but underestimates the granulated cork figure of 0·34/35. This would not be too important if the authors had not discussed the effect on capacity of using better insulation materials; it does not take into consideration the difference already existing between the materials used.

The section of the paper headed " Intermediate Insulation " deals with the problem of condensation on steelwork, and states that it is common practice to increase temporarily the insulation by a layer of sawdust. In my opinion it is unsound in theory and aggravates the problem in practice. Any intermediate insulation must be properly sealed to prevent entry of moisture, which destroys its value.

I agree with the remarks on the heat leakage at hatch plugs, which is 6·7 per cent of the total refrigerating demand and approximately 14 per cent of the total heat leakage. This applies only to the fully refrigerated ship, for if there is an insulated 'tween deck only with plug hatches above and below, this figure will reach approximately 30 to 35 per cent of the total heat leakage. One insulation firm is experimenting with a hatch plug which combines lightness with rigidity and which will have a considerably higher insulation value, the material used being a reinforced plastic which will withstand very high impact.

The heat leakage for brine leads is given as 45,000 B.Th.U. per hour. If we assume brine leads to be in a box 4ft by 2ft and having a length of 200ft, this gives a heat leakage of 0·25 B.Th.U. per square foot per hour per degree Fahrenheit, which is equivalent to a thickness of insulation of only 1in. Since brine leads usually have 4in to 6in insulation, the authors have either overestimated the leakage or the insulation fitted is completely inefficient. The latter explanation is probable, since it is usual to insulate the brine leads in a similar fashion to the insulated holds. There is a world of difference, however, since for brine leads the coldest spot is in the centre of the insulation and not on one side of it. This introduces the question of continuous vapour penetration, which arises only intermittently, if at all, on the general insulation. It is possible, where the material used on brine leads absorbs moisture, that this vapour is soaked up in the material, destroying the insulation value of five-sixths of the insulation material.

Mr. S. J. Duly : We have looked at the paper with an eye to assessing the influence of the insulation becoming damp. The flow of heat through the insulation on board the ship discussed amounts to 502,000 B.Th.U. per hour for 600,000 cubic feet of insulated space under the conditions stated, with the conductivity of the insulating material taken as 0·27 B.Th.U. in the customary dimensions. This would be for dry insulation, but although hydroscopic moisture would have very little effect on the insulating power of the material, accumulations of free water may easily double the conductivity. A year ago I measured the moisture in fourteen samples of granulated cork from a cold store on shore, and in eight samples I found there was between 50 and 110 per cent of water, based on the dry weight of the cork. This would more than double the amount of heat flowing through the walls from the outside.

The safety factor allowed on board ship by providing thicker insulation than is necessary theoretically might be reduced if the assumption could safely be made that the insulation would remain in its original dry state. The conditions which lead to the condensation of moisture within insulation have been investigated by Carl Munters, and as a result he has designed a process to maintain insulation permanently in its original dry condition. This process has had a notable success in Germany, where eight fully refrigerated ships have had their insulation maintained in a dry condition by this process, and the provision rooms in sixty vessels in service and under construction also have the insulation protected and kept permanently dry by the simple method of dehumidification.

In the paper a graph shows how cargo space is lost to insulation and how this loss depends on the conductivity of the insulating material. A saving of 5 per cent of the total capacity has been effected in the eight vessels mentioned through the designers being able to depend on the conductivity remaining at its minimum value.

No doubt the authors will consider this technological advance and give their views on the thickness and efficiency of insulation which might result from the confidence of the designer that it will remain dry.

Mr. O. Bartlett : In Table VI the loss from evaporator rooms (which presumably include brine control rooms) is shown as 75,000 B.Th.U. per hour. Is this calculation based on the brine control room being an integral part of the evaporator room, and does it take into consideration the opening and closing of the entry door ?

I agree that much can be done to improve the design of insulated plugs and doors, and believe that insulators are trying to evolve the right sort of door, especially for the cooler entry. No doubt a saving in the structural members of hatch plugs can be effected by decreasing the number of separate plugs to a row.

I suggest that the losses in the evaporator room are high and that some method of reducing them might be devised. It would be interesting to know how much heat is lost each time a door is opened. It is common practice to fit an air lock, but how often it is used is a matter for conjecture. Unfortunately, a modern ship with many compartments and carrying a variety of cargoes calls for a good many entries in the course of a day to make various observations, but entries have been reduced in number by fitting injection controls coupled with long-distance radial thermometers outside the room.

It would again be interesting to know what is the difference in heat loss in a vessel where the evaporation room is completely isolated below the control room as compared with one where the evaporation and brine rooms are common.

Dr. H. Stafford Hatfield : Towards the end of the war the Admiralty investigated the thermal conditions in ships, and our unit developed means for measuring heat flow. This we applied to examining why the extensive cold rooms installed on our large new ships such as " Vanguard " gave such poor performance when tested for insulation by heat input.

As opposed to the refrigerated cargo ship, nothing stands in the way of giving such rooms a thorough and exact test, and this has been done for a great many years by measuring the heat input necessary to maintain such a room at a steady temperature. We can calculate from these figures an " overall K value "—the apparent thermal conductivity of the walls of the room. If these walls were plane surfaces covered everywhere with insulation of uniform thickness, this K value would approximate to that of the insulation material used as tested in the laboratory. We allowed for frames, beams and heat leakage via grounds, according to the rules, but no liberality in this allowance brought us to more than half the K value actually observed. The rooms insulated with aluminium foil gave an overall K value of about 1 in British units, while the foil measured in the laboratory gave 0·25 or less.

Our heat flow meters enabled us to get a detailed picture of the flow of heat through the walls and to account for the bad results by bad installation, local corrosion and water condensation. We imagined that our heat flow meters would be received as a boon and a blessing by those responsible for testing refrigerated cargo ships, but the time required for such tests makes them uncommercial. We carried out an extensive series of experiments on models of various typical steel structures, estimating the effect of insulating them by the electrical capacity method. As is well known, the electrostatic capacity between two more or less parallel surfaces of electrically conducting material in air is proportional to the heat which would be conducted through a solid insulator filling the space between them, because the lines of electrostatic force have exactly the same shape as the lines of heat flow.

Did the ships mentioned in the paper undergo Lloyd's warming up test ? This has no great value except as between identical installations, since it depends upon the heating up of the insulation, which has a far greater thermal capacity than the air in the holds. The thermal capacity of different forms of insulation varies greatly and, indeed, is the less, the better the insulant, so that Lloyd's test may give a picture which is the reverse of truth. Waterlogging raises the thermal capacity and diminishes the insulation value and so favours Lloyd's test.

Professor E. V. Telfer : Speaking from the practical naval architect's standpoint, I should like to see in the paper a lot of information about the weights of the machinery involved and the insulation involved in the situation. It is rather significant that such important items as the weight and what it has cost the ship designer to give the shipowner an insulated ship are entirely missing, and if the authors could include such information I am sure naval architects would be grateful.

Mr. S. J. Jones : You will notice the stress put on the effect of the stiffeners and beams on the overall effectiveness of insulation. Faulty insulation around these structural members causes not only severe losses by heat transfer, but often considerable nuisance value and expense in dealing with the problem of condensation on the other side of the bulkhead.

The necessity for high-grade workmanship in the application of insulation is stressed, and I have measured conductance figures more than 100 per cent greater than have been estimated, due to bad application by inexperienced labour. Two examples come to my mind.

In the first, cool air in the region of 45 deg.

Fah. passed through a duct, the duct passing through the deck. The duct was insulated carefully above and below deck, but a strength coaming was welded into the deck and the trunk attached to it. This generated a cold spot in the vicinity. In tropical and sub-tropical waters, when temperatures and humidities rose, condensation on the deck and vertical bulkhead was such that it was quite common to have about 6in of water underneath a bunk at the ship's side. Obviously, the cold air duct should have passed through the coaming forming a gap filled with insulating material.

The second example deals with the condensate drains from the cooling coil units in refrigerated cargo spaces. In numbers of instances some fresh air is introduced, and consequently moisture will be condensed on the brine coils, which is normally drained away beneath. Here is another source of trouble because so often little care is taken in avoiding metallic contact between the drain and the deck below, and the result is again condensation on the deckhead below and possible damage to cargoes within the hold.

The authors have mentioned the considerable fan power required for maintaining even conditions within the refrigerated space. This is a factor which will always be present in that, if an even temperature within a degree or so is required throughout such a space, then the quantity of air handled is a function of the rise in temperature which is allowable, and this in turn is bound up with the actual heat transmission or heat loss through the boundary walls. Therefore, the more efficient the insulation and the bigger the range of temperature allowable in the space, the less is the fan power required.

A very important assumption has been made by the authors in computing Table VIII, showing the total refrigerating demand for a ship with fan powers as listed. It has been assumed, when making these calculations, that the power required by the fans is proportional to the volume of air to be circulated ; this is true, but generally we have a fixed duct system and the power will vary as the cube of the air volume handled.

(*To be continued*)

Ash Deposition in Gas Turbines

INSTITUTION OF MECHANICAL ENGINEERS

No. I

At a general meeting of the Institution of Mechanical Engineers in London on Friday, April 24, 1953, a paper, "The Problem of Fuel-Oil Ash Deposition in Open Cycle Gas Turbines," was presented for discussion by A. T. Bowden, Ph.D., B.Sc. (Eng.), M.I.Mech.E., P. Draper, M.I.Mech.E., and H. Rowling, B.Sc. (Eng.), G.I.Mech.E., and abstracts are published elsewhere in this issue. We reproduce below some of the points made by speakers in the discussion.

Discussion

Mr. P. Lloyd, who opened the discussion, said that the paper was an excellent survey of a complex subject and gave an account of some important work. When we in this country had first started working on the application of residual oils to gas turbines at about the end of the war, there had been no way of knowing whether the problem that was being tackled was basically a chemical, physical, metallurgical or aerodynamic one ; but now, as the paper showed, a fairly definite pattern had emerged. But though the problem might have been defined and circumscribed, it was certainly by no means solved, as Mr. Draper has made clear in presenting the paper. For instance, even the problem of what was the bonding agent in these deposits formed at relatively low temperatures remained unanswered. Indeed, he could not help feeling that the problem as a whole was perhaps less simple than the paper and Mr. Draper's lucid exposition of it had made it appear. For instance, the current engine trials were inevitably being done at rather low cycle temperatures, and those higher temperature levels which the gas turbine needed to use if it was to do itself justice would inevitably introduce complications. Above 700 deg. Cent., for instance, not only vanadium pentoxide, but also some of the sodium vanadates, became liquid, vapour pressures were substantially higher, and the problem of corrosion, which Mr. Draper had rather belittled, might well assume major proportions.

There were so many points of detail in this work that were worth commenting on that it was rather hard to know where to start, but he wished to pick out one thing, namely, the question of combustion control. This work during the last few years seemed to him to be the biggest contribution that had yet been made to solving the blade fouling problem, for if an inert diluent was wanted, what could be better than the coke residue of the fuel droplets which one was handling, and if an absorbent was wanted for noxious liquids and vapours, what better than carbon ? But worsening atomisation, although it was easiest, was not necessarily the best way of achieving this control, and at the N.G.T.E., where they had been studying and applying this idea for some little time, they had been controlling combustion by the different method of varying reaction temperature with atomisation kept constant.

For this purpose they used a refractory-lined balanced vortex chamber arranged with a variable by-pass which enabled them to control the temperature at which the second stage of burning, the destruction of the solid residue, was carried out. They varied it between the limits of 1400 deg. and 600 deg. Cent. Over this temperature range the ratio of carbon to ash in the residues varied from 0·5 at the higher temperature level, where, of course, the combustion was most complete, to 20 or 30 at the low-temperature level, and it should be said that most of this change took place between 1000 deg. and 600 deg. Cent.; above 1000 deg. Cent. the combustion was substantially complete all the way. The exhaust gases from this chamber led to a fixed cascade of cambered blades (the same sort of rig as that to which Mr. Draper had referred), and in the results [illustrated in a slide] the operating temperature had been 500 deg. Cent. There could be seen clearly the increase in deposition rate and the rapid rise in rate of build-up as one went from 600 deg. to 1000 deg. Cent. But above 1000 deg. Cent. there was a sudden —and to them unexpected—fall, leaving the maximum deposition rate at 1000 deg. Cent. This was a new effect which they could only ascribe to vaporisation of the ash-forming compounds carrying them through the cascade in the vapour form, the cascade not being cooled. It was quite possible that under conditions of that sort where the gas was being expanded through an actual turbine, condensation might occur at the low-pressure stages.

That vaporisation was quite an important factor in these tests was shown by the appearance on the convex surface of some blades exposed in this cascade of crystalline deposits. These deposits had recently been identified by the Fuel Research Station as sodium vanadyle vanadate, a compound which turned up in quite a number of these deposits, and it was worth remembering that whatever might happen to the sodium in the ash, the vanadium in the form of V_2O_5 could, if equilibrium was reached, pass into the vapour state and then condense again during the expansion.

In conclusion, he wished to make a plea for more engine trials of the kind that C. A. Parsons Ltd., had done, and for detailed observation of both deposition and corrosion effects. The figures that they wanted to determine were the rates of deposition in weight per unit area and time and the corresponding corrosion rates. It was only by building up a quantitative picture that they could expect to work out the cures for this troublesome ailment.

Captain (E.) H. Farquhar Atkins said that the paper was of very great interest to the Royal Navy, as they had to be prepared to burn residual fuels in their gas turbines, and he was afraid that they would almost always have to expect to have increased ash content by salt water contamination, making the problem even more difficult than it would be on shore.

Neglecting the effect of any change in viscosity on particle size, if the fuel particles leaving the burner were hotter or the air in the primary zone was hotter, would the particles evaporate much more quickly or were these effects negligible ?

He hoped that the range of particle size which gave comparative freedom from deposition was a large one, as in naval propulsion engines and generating sets which had to be operated at widely varying loads it might not be easy to arrange to provide the burner pressure to give the correct particle size.

In general, the combustion temperature and residence time would vary with load, which meant that the pressure would have to be varied to keep the right particle size, but probably not in the same way as the quantity of fuel required by the engine demands. Possibly air-blast burners provided an answer.

If they were compelled to use additives—and he was afraid they would be—then he would like to make a plea for the most homely substance possible, sand rather than phosphorus, and that it should be made simple to mix in the fuel in the correct quantity.

Mr. R. G. Voysey stated that one of the conclusions rather worried him as expressed in the fourth paragraph under the heading "Conclusion," where it was stated : "It has been found possible, by controlling the particle size of the fuel droplets, to limit combustion in such a way that sufficient carbon remains in each particle after it leaves the combustion chamber to hold the ash in an innocuous form." These last words gave the impression that it tended to be physical rather than chemical. He was worried about this, because such a conclusion must condition future work and, more particularly from the engineering point of view, must condition solutions. They must have an open mind about mechanisms, but they must look towards solutions.

The lesson which had seemed to follow

from the Boiler Availability Committee's work had been that there was a very large chemical and especially physico-chemical aspect of the matter, in the action at surfaces. It came in in this way, that this report concluded that the volatiles had really little influence in making ash innocuous. He thought that was certainly wrong as a matter of emphasis, and he thought it might even be unjustified. He had in mind that there was plenty of data from boiler work which showed that, if one liked, adventitious ash—ash added after combustion—had a marked effect. For instance, with pot tests burning solid fuel, tests in which fuel was burnt with an ash stream upwards and ignition from the top, as long as there was a green zone under the fuel there was no deposition of sodium or ash in the main stream, and yet as soon as that green zone disappeared two remarkable things happened.

One was that deposition commenced, and another—which he found great difficulty in explaining—was that the spectrum of sodium, which was previously apparently suppressed, immediately appeared. This was in gases as hot as 1200 deg. Cent., and more marked cloaking effect would be expected in gases under these conditions. He felt that even on the authors' own facts, and in particular the remarkable effect of silicon, there must be a strong chemical effect. In the boiler field it was known, for instance, that an alkali wash on boiler tubes would inhibit for some considerable while the deposit coming on at all, and then at the end of the time, which was irregular, deposits would ensue quite sharply and rapidly pile up.

If it was thought that the mechanism was to restrain the combustion and that to restrain the total burn-away time would give the mechanism by which ash was held, they were condemned only to think in terms of fuel additives, which in general were expensive and bulky. On the other hand, if they could contemplate that an injection downstream of a water solution, or even a dry powder, could have an effect—and there was evidence from boiler work that this was so—then the possible means of attack on this problem would be expanded and in particular—and most important from the engineering point of view—they would be cheapened and simplified.

He did not think that justice had yet been done to the refractory bed. The first fact was that the pressure drops given for this refractory bed suggested that it was being operated very much up in the turbulent region. A pebble bed was rather an unfortunate thing in that a Reynolds number much larger than 10 resulted in turbulent motion—a Reynolds number of 20 in cases of ½in pebbles at 600 deg. Cent.—which implied a velocity well under $^1/_{10}$ft per second and he thought $^1/_{50}$ft per second, and the pressure drops here suggested that for the result quoted the flow certainly was not streamlined. It would be interesting to know whether tests had been done at very low velocities. He would also refer to the importance of chemical effects. Just as in the boiler an alkali wash could have a profound effect on the onset of deposit, it must equally apply that the nature of the surface of the refractory must have a profound effect on the onset of collection of deposits, and in this case they must maximise the collection.

Mr. Lloyd had already pointed out that a refractory was usually receptive to vanadium compounds. It was well known in boilers using refractories in the combustion space that vanadium tended to be held down, whereas in all-steel boilers the vanadium tended to appear in a cold stack.

(To be continued)

Failure of High-Pressure Fuel Pipes

There is described below the work carried out by C.A.V., Ltd., to establish the cause of failures occurring in fuel pipe-lines. It was found that the pipes were commonly subject to resonant vibrations and suffered fatigued fractures. A simple rubber damper attached to the middle of each pipe is stated to be a satisfactory solution.

THE breakage of high-pressure fuel pipes has been experienced with many, if not all, makes of diesel engine from time to time, and has given rise to some investigational work in the past without, however, achieving any fully satisfactory solution to the problem.

The frequency of failure varies greatly both from engine to engine and from operator to operator, from a pipe life of three years or even longer to frequent failure after a few weeks.

Failure usually consists of a break, more or less transverse, generally at the nipple, but with some terminations other types of failure, causing leakage rather than breakage, occur first. Past work has been done on the fatigue strengths of the normal single-taper pipe ends, some other forms of termination, and on pipes of some different materials.

Although high-pressure fuel pipes have been supplied generally by the engine builder, C.A.V., Ltd., thought it logical to investigate the whole problem. A review of service practice and experience was first made, to discover if there was any fully satisfactory solution already in being. Concurrently, a laboratory investigation was made, the primary cause of failure established, and a number of possible cures examined. As a result, a solution was devised which appears to be entirely satisfactory and generally applicable.

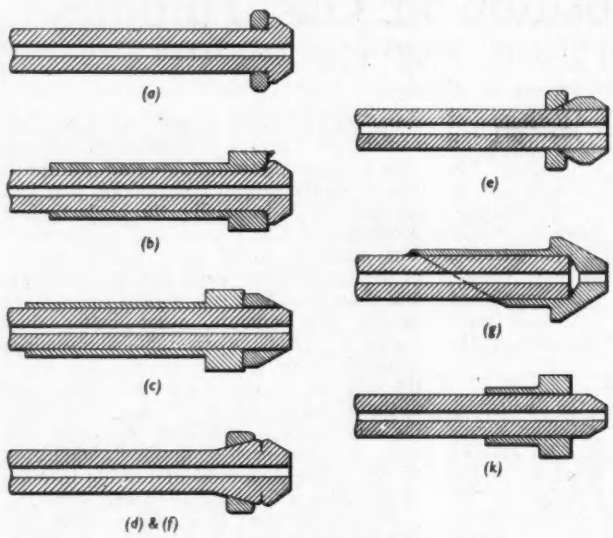


Fig. 1—Some Widely Used Pipe Terminations

Present Practice

High-pressure pipes are almost invariably of mild steel, and, in engines of up to 10 litres, or thereabouts, of 6mm O.D. There are many different terminations, however, some of which are shown in Fig. 1. Of these, (*a*) to (*f*) have been widely used, and there are a few others not in common use and not illustrated. The commonest termination (Fig. 1(*a*)) is the single taper made by upsetting or swaging with a hand tool, with a steel backing washer.

The double cone end has generally, but not invariably, been found to be an improvement over the single taper as regards breakage, but with some trouble due to washer failure and consequent leakage. The loose brass olive was sometimes found to reduce breakages, but with an increase of leakage trouble.

Various forms of pipe clamping have been tried and many are used. They are generally found to improve matters, but seldom, if ever, to afford complete freedom from pipe failure.

Laboratory Investigation

Most pipe failures examined appeared to be fatigue fractures due to transverse bending. The following calculations are of interest.

If a high-pressure pipe 20in in length is held firmly by the pump at one end and the nozzle holder at the other, a displacement of the middle of 0·1in produces a stress at the ends of about 10 tons per square inch. This is the fatigue limit of the normal single-cone terminations. The lateral displacement of one end of the pipe relative to the other which would produce this stress is about 0·4in, but vibration of the pump relative to the engine of this amount is, of course, inconceivable. A high-pressure fuel pipe, clamped at each end, is a highly resonant system, however, and if there is a vibration of one end relative to the other of the same frequency as the natural frequency of the pipe, stresses greatly in excess of those corresponding to the amplitude of the exciting vibration can be built up.

An amplification factor of 60 is quite possible, so that for a 20in pipe a vibration of one end relative to the other of 0·007in would be enough to excite a vibration of amplitude 0·1in at the middle of the pipe, producing a stress equal to the fatigue limit at the ends. Such a vibration must be reckoned reasonable. The amplification depends upon the damping which is discussed later.

It can be shown that the frequencies of pipes and probable engine or pump frequencies are roughly the same. The lowest natural frequency of a 20in pipe in transverse vibration is 100 c/s. This is equal to the pump cam frequency (or engine firing frequency) of a six-cylinder engine at 2000 r.p.m. It seems probable, therefore, that pipe oscillations are excited by even the fundamental of the engine firing frequency, and certainly by low harmonics of it.

The stresses actually occurring in pipes were explored by strain gauge measurements on a typical six-cylinder D.I. engine. The gauges were attached to the pump ends of the pipes, as failure occurs more frequently at this end, and, in any case, the stresses at the two ends are not likely to differ greatly. Results are shown in Fig. 2. A record of the vibrations resulting from plucking a pipe with the engine not running is shown in (*a*). The very slow decay of the oscillations is an indication of the very low damping of the system, showing that resonances of large amplitudes are likely.

Shown by (*b*) is a record taken at a speed chosen at random to indicate the general level of stress in the pipe ; at certain speeds, however, much larger amplitudes are found.

Graph (*c*) shows the most severe resonance observed on this particular engine. The fact that the vibration is resonant is demonstrated in (*d*), which shows the effect of laying a finger lightly on the middle of the pipe. This small amount of damping was enough to reduce the stress many times.

The largest stress observed on this engine was

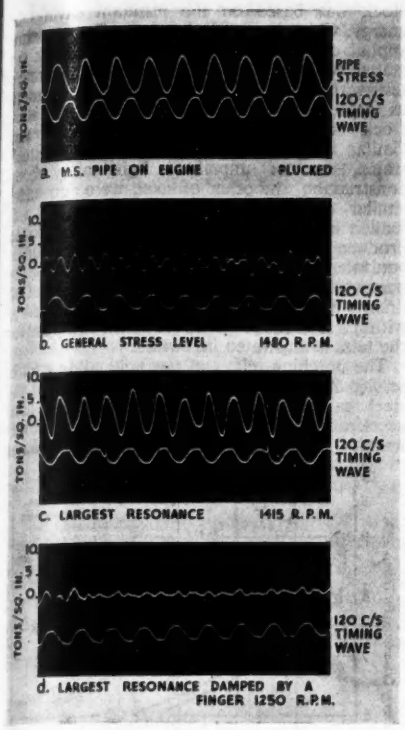


Fig. 2—Vibration Stresses

about ±6 tons per square inch. This is well below the fatigue limit of the single taper ends (10 tons per square inch), but it is to be expected that the actual magnitudes of such resonant vibrations will vary greatly from engine to engine and condition to condition. Even this installation, therefore, cannot be said to be out of danger. Several engines have been examined, and maximum stresses ranging from 5 to 20 tons per square inch have been found. This points to the conclusion that resonant vibrations resulting in bending stresses reaching the fatigue limit of the pipe ends are the primary cause of failure.

Whatever else is done, it is of the first importance that the mounting of the pump on the engine should be as rigid as possible, since other things being equal, pipe stresses are proportional to the amplitude of vibration of the pump with respect to the engine. In practice, however, it would appear to be seldom, if ever, possible to achieve so rigid a system that pipe vibrations do not occur.

The means of reducing failures include increasing the fatigue limit of the pipe material and joint; increasing the damping capacity of the pipe material, or imposing restraint on the pipe, e.g. by clamping.

Fatigue Limit of Pipe Materials and Terminations

Measurements of the fatigue limits of pipes of various materials with different terminations were made. A simple test rig was used, in which a short length of pipe, held by the termination under test, was subjected to the Wohler test. The results are given in Column 3 of Table I.

The expected fatigue limit of the normal mild steel pipe itself is 12 tons per square inch. Thus, the double-cone end is, in fact, slightly stronger than the pipe itself, as is shown by the fact that such ends generally break ¼in or so away from the nipple.

The brazed terminations were also fatigue tested and it was found that, when properly made, they were as strong as, or stronger than, the pipe itself. Although the single-cone end is slightly weaker in fatigue, the loss compared with double-cone or brazed ends is small, and is shown later to be trivial compared with variations in damping factor.

The effect of the termination is somewhat greater with other materials, presumably because they are more notch sensitive. Thus, with stainless steel there is an increase from 14 tons per square inch for the single-cone end to 22 tons per square inch for the double-cone end. If such materials were to be used it would be worth while also using the double-taper end. Apart from stainless steel, no material tested shows any considerable advantage in fatigue limit over mild steel.

Damping Factor

The damping factor increases with stress and with the amount of cold working to which the test piece has been subjected; but if run at a stress near the fatigue limit the damping factor decreases with time. The relevant quantity is the stable value after running at just below the fatigue limit. Measurements under this condition have been made for most of the promising materials.

Table I

Material	End	Fatigue limit T, tons/sq in	Damping factor, per cent energy loss/cycle, after running at stress T'_d	T' tons/sq in	E 10^3 tons/sq in	$T'd/E$
1	2	3	4	5	6	7
Mild steel	C.A.V.	9·6	0·07	9·0	13·5	4·8
	Double cone	12·4	0·07	8·0	—	4·2
Hard nickel	C.A.V.	9·0	0·06†	—	13·0	4·1
Soft nickel	C.A.V.	9·5	0·095	8·0	13·0	5·8
Half-hard Monel	C.A.V.	12·0	0·05	9·0	11·0	4·1
Soft Monel	C.A.V.	10·5	0·03	7·0	11·0	1·9
Everdur	C.A.V	10·0*	0·018†	—	6·8	2·6

* Maker's value.
† These materials were not run to stabilise the damping factor since the initial values quoted here are too low to be of interest.

In order to avoid failure, it was generally found necessary to run at a stress appreciably below the fatigue limit, probably because of occasional increases of amplitude caused by variations of the mains supply to the test equipment. In Table I the highest stress at which it was found possible to run is given in column 5 (T'), and the final damping factor (d) is given in column 4. The merit of any given material and termination is given by the factor $T'd/E$ in column 7.

Some tests were also made on stainless steel. Earlier fatigue measurements gave a high strength (22 tons per square inch) with double-cone ends. Later samples from a different batch, however, made to measure damping factor, failed to give this high fatigue limit. Attempts to repeat the original behaviour have so far failed, but there remains a possibility that stainless steel would show a worth-while advantage over mild steel.

Apart from this possibility, the value of $T'd/E$ given in the table shows that no material is considerably better than mild steel. Attention was therefore given to the reduction of working stresses by means of dampers, the possibility of which had been clearly demonstrated by the effect of merely laying a finger on a pipe described above.

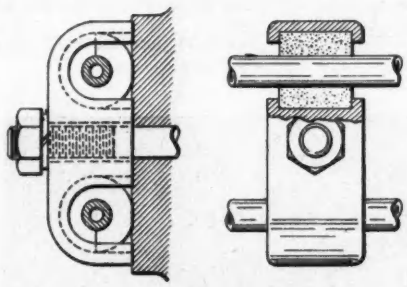


Fig. 3—Synthetic Rubber Damper

Pipe Dampers

Strain gauge measurements were made with various kinds of clamp on an engine which gave pipe stresses, without clamps, of up to 11 tons per square inch. It will be appreciated that in a system such that the high stresses are due to resonance, the stresses found may be capricious from one occasion to another. It is therefore necessary that for any device to be regarded as offering a cure for the breakage trouble, it must give stresses very substantially less than the fatigue limit; the target set in these experiments was one-half the fatigue limit, i.e. with single-cone ends on mild steel pipes, a stress not greater than 5 tons per square inch.

The arrangement most likely to be effective is one in which each pipe is connected to the engine structure by some material capable of absorbing vibrational energy. It was found that attaching the mid-point of each pipe to the engine by means of a clamp lined with sponge rubber was very effective, provided the clamp was not fully tightened. With the sponge-rubber-lined clamp fully tightened, however, or with rigid (steel) clamps to the engine, the particular resonance giving the highest stress, with pipe unclamped, disappeared, but resonances appeared at other engine speeds which were generally almost as serious as the original one.

A similar result was obtained by clamping the pipes together in pairs with either steel, wood-lined steel, or even sponge-rubber-lined clamps not fully tightened. It was concluded that of these palliatives the most effective was clamping to the engine with resilient, energy-absorbing material interposed.

The C.A.V. synthetic rubber damper (Fig. 3) was then designed. It consists of a rubber bush which fits the pipe, the outside surfaces being held in a metal housing which fits, but does not deflect, the rubber. The effect of these dampers in reducing stresses is shown in Table II. Subsequently, tests were made on two other engines with similar results, an occasional stress of 4 tons per square inch being observed on one pipe. Fig. 3 shows a twin pipe damper.

Table II

Pipe	Unclamped worst resonance		Clamped worst resonance	
	Speed	Tons/sq in	Speed	Tons/sq in
1	1475	11	1200	2
2	1630	8	1800	2·5
3	1290	7	1900	3
4	1440	7	1800	2
5	1450	4	1600	1·5
6	1580	11	1500	4

Endurance tests were made in which the rubber was stressed much more severely than it would be in practice, by vibrating a pipe in it. Runs were made with the damper dry at room temperature, and at 80 deg. Cent. with gas-oil dripped on it. No considerable wear was found in 100 hours and in view of the much more severe duty which rubber components often perform, it is expected that these dampers will last many thousands of

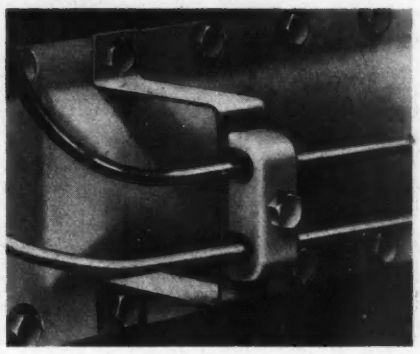


Fig. 4—Double Pipe Damper

hours ; it is proposed, however, that the rubber should be replaced at engine overhauls.

Recommendations on Pipe Installations

Pipes should be clamped at about the mid-point to the engine structure. Where, to keep pipes of equal length, it is necessary to put a coil into a pipe, the coil should be neglected when estimating the mid-point. The layout should be such that the pipe is as far as possible parallel with the axis of the damper. If a major part of either half of the pipes makes an angle greater than 45 deg. with the axis of the damper, the damper may be ineffective.

The pipe should be smooth at the point when it goes through the damper, and in forming the ends care should be taken to avoid notching the material. Flashes should be removed only if essential to permit assembly ; if they must be removed great care should be taken to avoid gashing with the file.

Care should be taken when forming nipples with a hand-operated nipple forming tool that undue pressure is not applied as this distorts the nipple and reduces the bore of the pipe, and, finally, pipes should be cleared either by blowing through with compressed air or fuel.

If stored, ends should be blanked off to exclude air.

The damper of the form shown in Fig. 3 is available in single, double or triple-pipe units.

Energy Consumption Tests with Steel and Light Alloy Trains

Tests carried out by London Transport with trains of steel and light alloy construction have confirmed that the savings in energy consumption due to the saving in weight justified the extra capital cost of the light alloy cars.

A SERIES of comparative tests have been carried out by London Transport with two " R " stock trains, one of steel and the other of light alloy construction. In a report on these tests it is pointed out that the annual cost of electricity used by London Transport railways is about £3,500,000, and for this reason it will be appreciated that even relatively small savings in the energy used for train movement can add up to a considerable amount.

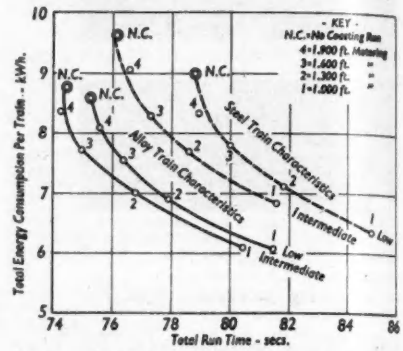
Of all the electrical energy supplied for train movement, it is stated, the kinetic energy of a train at braking, over 40 per cent of the whole, is dissipated in the braking system, unless it can be recovered in part with a regenerative brake and used again. The other 60 per cent, which does no useful work, is lost in the current rails, starting resistances, traction motors, gears, bearings and in friction and wind resistance. By reducing train weight the current required for the kinetic energy, proportional to the mass, the square of the speed, and the stops per mile, is directly reduced. There is also a corresponding reduction in all the indirect losses incurred in producing the kinetic energy, except for wind resistance.

By the use of higher acceleration and braking rates a given distance can be covered in the same start-to-stop time with a lower maximum speed and hence a reduced energy consumption, although a higher proportion of driving axles with a greater weight and cost of traction equipment may be necessary. The general trend in London Transport design has been to increase the proportion of driving axles and to fit retardation brake control equipment, for maximum use of wheel/rail adhesion.

To further this policy the District Line post-war " R " stock steel cars have half the axles motored, giving 55 per cent of the tare available for adhesion, and a higher acceleration (2 m.p.h/sec^2.), with a lower maximum speed, than the older District Line " Q " stock. For a given distance and run time the " R " stock has a lower energy consumption despite the greater total train weight, due to the extra equipment, and a rather higher maximum demand on the substation during the notching period. To combine the benefits of lower maximum speed and reduced weight, ninety " R " stock cars are built with light alloy body construction and lightweight equipment. Of these cars, a complete eight-car train was supplied with unpainted bodies and roofs, and was one of the trains used in the tests described.

The original decision to purchase light alloy stock was based on the resultant savings in energy, which were calculated to offset the extra capital cost of the cars. It was to check the actual savings that the series of comparative tests with steel and light alloy trains was arranged as soon as a complete train of light alloy stock became available. For the tests two similar four-car District Line " R " stock trains, one of unpainted light alloy body construction, the other of steel, were run under similar conditions. Each four-car train was loaded in turn with cast iron brake blocks to produce a total weight equal to half that of its equivalent eight-car average loaded train (fifty passengers per car). The wheel diameters of all driving axles on the two trains were matched to within a total range of ½in. A coach equipped for the tests is illustrated herewith.

The notching relays of the light alloy cars in service have a lower setting than those of the steel cars, to give approximately the same acceleration with lower maximum current demand. In addition, the field shunt resistances



Comparative Energy Consumption of Trains over Half-Mile Run

Average of two special kWh meters in substation includes standing load of two motor generators on train.

are arranged so that the light alloy cars run with a higher percentage of full field than the equivalent value for the steel cars, so that the two types should have the same speed-distance characteristics with a lower current for the lighter train.

All tests were made over a half-mile run, start to stop (the average distance between stations on the inner sections of the District Line), in both directions of running, using one of the four roads between Acton Town and South Ealing. This road is normally supplied by a substation at each end, but to avoid difficulties it was fed during the tests from only one end by Northfields substation. For this reason four-car, instead of full-strength eight-car, trains were used, so that the voltage drop in the current rail, and hence the voltage at the train, should approximate to that with an eight-car train on a line fed from both ends.

Readings were taken during the tests with recording voltmeter, ammeter, and two special kilowatt-hour meters in Northfields substation ; and on the train itself by a traction recorder of line voltage, total motor current on one car, and train speed, from an axle-driven d.c. generator. Current-on and braking times were also indicated. By using two 15W mobile V.H.F. radio telephones, continuous contact was maintained between the two groups of observers. This enabled the tests to be made with the minimum delay during the limited period of the special line possessions, and on one day thirty ½-mile runs were made in under three hours' testing time.

The test road was measured and marked for both directions to indicate shut-off points for runs with varying motoring and coasting distances, with further marks for location of braking points. A series of tests was made with varying motoring distances, shutting off and coasting at 1000ft, 1300ft, 1600ft and 1900ft, and making no coasting runs, where the brake was applied as power was cut off in both directions. Each test was made with three field strengths, 100 per cent, 80 per cent, 53·5 per cent full field for the steel train, and 100 per cent, 84 per cent and 56 per cent for the light alloy train.

A constant rate of braking was used on all tests with both trains. To obtain this, braking points were estimated for all the various runs,

Coach Equipped for Tests

and the driver each time made a "full service" application of the E.P. brake with retardation control at the braking point, and then did not move the brake handle again during the stop. This called for skilful judgment of braking distances, but with practice it was possible to come to rest within plus or minus 10ft of the half mile mark.

Spot checks of the train traction recorder voltage and current readings were made during the tests, and the speed readings were checked each day by timing runs at constant speed over quarter-mile sections. The total run time was measured on the train by stopwatch, as was the current-on time, to check the speed of the clock-work-driven charts.

Before each run the train compressors and heaters were switched off, so that the only load measured by the substation was that used for traction, plus two motor generators supplying 50V d.c. control current.

The curves we reproduce herewith show the results for the two trains operating on their low and intermediate speed characteristics, each point being the average of about six half-mile runs start to stop.

The results may be considered in several ways. First, the two curves which have the closest no coasting (or minimum) run time, the intermediate characteristic for the steel train and the low-speed characteristic for the light alloy train, are in Table I compared for the same total run time based on the steel train with the usual allowance for make-up time.

TABLE I

Characteristic	No-coasting run time	Run time with make-up	Energy per train	Total weights
	Secs.	Secs.	kWh	Tons
Intermediate steel ...	76·1	80·1	7·20	148·2
Low-speed alloy	—	80·1	6·31	127·0
Saving	—	—	0·89	21·2
Per cent	—	—	12·4	14·3

This saving of 0·89kWh per train or 0·22kWh per car of light alloy stock for the half-mile run gives a corresponding figure of approximately 0·25kWh per car, or a 12½ per cent saving, for a run of just over ¾ mile, the weighted average distance between stations for the whole of the District Line.

The second comparison is for the two trains both running on their low-speed characteristic, i.e at 100 per cent full field. The motors on both trains will have the same tractive effort/speed characteristic, after notching is complete, and the light alloy train with its lower mass would have a higher average and maximum speed. This is reflected in Table II by a reduction in no-coasting run time with the light alloy train.

Two conditions are considered : the same allowance for make-up time with both trains, so that part of the saving would be in reduced run time, and part in energy consumption ; and the same run time for both trains, based on the run time for the steel train, so that all the saving would be in reduced energy consumption. Power would be shut off earlier in the run for this case, with the faster train, to obtain equal run times.

TABLE II

Low-speed characteristic	No-coasting run time	Same make-up		Same run time	
		Run time	Energy per train	Run time	Energy per train
	Secs	Secs	kWh	Secs	kWh
Steel	78·7	82·7	6·89	82·7	6·89
Light alloy ...	75·3	79·3	6·48	82·7	5·88
Saving... ...	—	3·4	0·41	—	1·01
Per cent ...	—	4·1	6·0	—	14·7

The general shape of the curves illustrates clearly the important principle that a large increase in energy consumption is required to produce a small saving in run time, or conversely, and more important, how much energy can be saved by shutting off power early and coasting, with only a small increase in run time. For the steel stock intermediate characteristic the energy consumption is reduced by 1·27kWh (13·2 per cent) and the run time is increased by only 1·0 sec if power is cut off after 1600ft (point 3) compared with the no-coasting run.

The economies of light alloy, compared with steel construction, can be used either to give the same run time for a given distance with a lower energy consumption, or to have a shorter run time with the same energy consumption, or to combine a smaller saving of both time and energy. The actual distribution will depend on the way in which the trains are driven, and the particular train characteristics provided.

In the case where all the saving is required in energy, it is clearly desirable to adjust the train characteristics so that the saving with a light alloy train will be assured however the train is operated. Some idea of the different effects of driving and of train characteristics is given in Table III, with 1600ft motoring (point 3) in all four cases.

TABLE III

	Low speed		Intermediate	
	Run time	Energy	Run time	Energy
	Secs	kWh	Secs	kWh
Steel train ...	80·0	7·79	77·1	8·34
Alloy train ...	76·4	7·50	74·9	7·76
Saving	3·6	0·29	2·2	0·58
Per cent ...	4·5	3·7	2·9	7·0

Or comparing the intermediate steel stock with the low-speed alloy stock characteristic, the figures are :

	Run time	Energy
	Secs	kWh
Intermediate steel	77·1	8·34
Low speed, alloy	76·4	7·50
Saving...	0·7	0·84
Per cent	0·9	10·1

Results from the measurement of ampere seconds from the current traces both in the substation and on the train confirmed the above figures, which were all taken from the special kilowatt-hour meters in the substation.

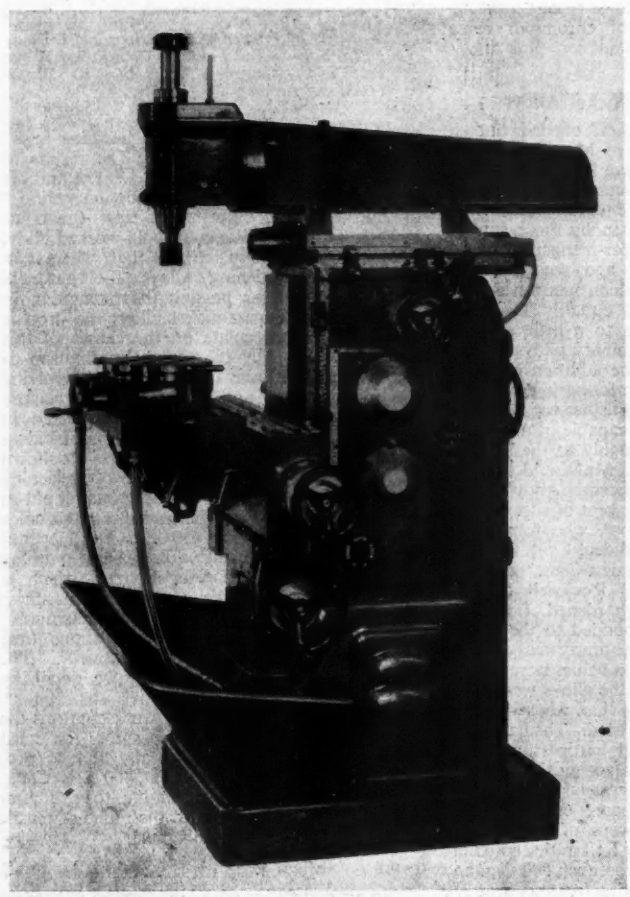
In conclusion, it is pointed out that the calculated savings in energy consumption due to the saving in weight, which were originally used to justify the extra capital cost of the light alloy cars, were confirmed by the results of the tests.

An Improved Punch and Die Milling Machine

WE have received from the Rockwell Machine Tool Company, Ltd., of Welsh Harp, London, N.W.2, particulars of the latest design of the Thiel punch and die milling machine, which incorporates a number of improvements.

In this new machine, as can be seen from the illustration we reproduce on this page, the motor and switchgear and all the gearboxes are totally enclosed within the column. Through a new design of speed and feed selector dials there is a choice of twelve speeds from 60 r.p.m. to 1200 r.p.m. for the horizontal and 90 r.p.m. to 1800 r.p.m. for the vertical milling spindles. The eight feeds from ¼in to 6in per minute can be chosen independently from the spindle speeds. Each selector dial consists of three superimposed cones engraved with numbers and by reference to a table the various speed and feed combinations can be ascertained and set by adjustment of the dials.

The sliding commutator driving motor incorporates a brake which is applied by the commutator sliding on to a friction cone when the circuit to the motor is broken. Power feeds for the three table movements are provided and dual engagement levers are incorporated for the longitudinal table traverse. The length of travel for the movements can be limited either by the trip dogs, when using the machine with power feeds, or by working to fixed stops when using the machine with manual feeds. Apart from the headstock traverse of 8in the overarm can be moved out to give a maximum throat distance from the centre of the vertical milling spindle to the machine face of 29in. This wide range of adjustment facilitates the machining of large fixtures and components of difficult shape where relocation would be complicated and slow. The overarm is moved by means of a simple rack and pinion mechanism.



Punch and Die Milling Machine

The vertical drilling and milling head swivels through a full circle and the collets of vertical and horizontal spindles are interchangeable.

Either the drilling and milling head or the slotting head used on the machine can be left in position whilst the machine is used for horizontal milling. Drive to the vertical or slotting unit can be disconnected by means of a small lever fitted near the end of the overarm. A universal dividing head suitable for direct and indirect indexing is available and can be used horizontally or vertically. This head swivels through a full circle and its equipment includes a collet attachment, outrigger steady, tailstock, faceplate and three index plates.

Slip gauge platforms provided for all three movements of the machine enable it to be used for jig boring using the co-ordinate system.

Metallurgical Topics

Tin-Nickel Alloy Plating

PROTECTIVE and decorative coatings of tin-nickel alloy were introduced about two years ago by the Tin Research Institute. In a recently published paper, J. W. Cuthbertson, N. Parkinson and H. P. Rooksby* have described much of the laboratory work which was carried out before and during that period on the conditions of deposition which yield the most satisfactory results. The alloy deposits are obtained from solutions containing stannous chloride, nickel chloride and fluorides. The presence of fluoride is essential for reasons which are suggested by the authors. The tin-nickel deposits are bright, hard, do not scratch easily and have a good range of corrosion resistance. They consist of a single phase, NiSn (nickel 35, tin 65 per cent by weight). This compound ceases to be stable at temperatures above 300 deg. Cent. and decomposes at higher temperatures into Ni_3Sn_2 and Ni_3Sn_4. The first commercial plant came into operation in England in 1951, the first in the U.S.A. a few months later, and there are now several others. The largest of these has a capacity of 2000 gallons and has now been working for about a year. Although the process has basically proved satisfactory, experience with these plants has enabled some practical difficulties to be overcome and improvements made. Further work is in hand directed mainly towards finding additions to improve the brightness of the deposits and to combat pitting, which has occasionally proved to be troublesome.

Considering the very short time that the new process has been in industrial use, the results obtained can, it is claimed, be regarded as most gratifying. Tin-nickel plating is being used for finishing a wide variety of articles, including automobile fittings, domestic goods, battery cases, &c. The plate is quite as resistant as chromium to atmospheric tarnishing, and has, in many people's opinion, a more pleasing colour, the bluish tinge of chromium being replaced by a characteristic faint rose-pink tint.

Copper-Manganese-Nickel Alloys

THE well-known researches, carried out at the U.S. National Bureau of Mines under the direction of R. S. Dean, have led not only to a practical method of production of electrolytic manganese but also to the development of a number of useful alloys. Among those studied were the hardenable copper-manganese-nickel alloys. These were long ago recognised as belonging to the class in which manganese and nickel contents were nearly equal.[1] The composition MnNi corresponds to a little over 51 per cent of nickel and all binary alloys in that region are glass brittle. The addition of about 20 per cent of copper is necessary before the alloys show any ductility. Further work showed that the composition range capable of maximum hardening corresponded roughly to the pseudo-binary alloys of copper and MnNi and that the copper should exceed 50 per cent. Alloys of this type containing 50 to 60 per cent of copper were studied by Dean and others[2], who found that a softening treatment at 650 deg. Cent. followed by ageing at 350 deg. to 450 deg. Cent., produced maximum hardness (about Rockwell C45 or Vickers 440). Material hardened from the cold-worked condition responded to the ageing process more rapidly than the unworked solution-treated material. Elongation values were greater at all hardness levels when the alloys were made from electrolytic manganese than when ordinary commercial manganese was used. The hardening process was very slow and hardness could be controlled by regulating the ageing times.

In 1948 a British patent[3] was taken out by the Chicago Development Company covering alloys containing 50 to 80 per cent of copper with manganese and nickel in a 1 : 1 ratio, softening treatments at temperatures between 500 deg. and 900 deg. Cent., and hardening treatments at 350 deg. to 450 deg. Cent. The specification contains a detailed statement of many properties of the alloys, evidently based on Bureau of Mines work, and the preferred composition was given as 60 : 20 : 20 copper-manganese-nickel. A point was made that the alloys compared favourably with copper-beryllium alloys.

HARDNESS IN RELATION TO TEMPERING TEMPERATURE

The German investigators, O. Dahl and K. L. Dreyer[4], who refer to the British patent quoted above, have reported on the properties of the 60 : 20 : 20 alloy in relation to tempering temperature. Sheet in the soft condition produced by heating for 1 hour at 800 deg. Cent. and in the cold-rolled condition (50 per cent reduction with intermediate annealing) was tempered at temperatures from 200 deg. to 700 deg.

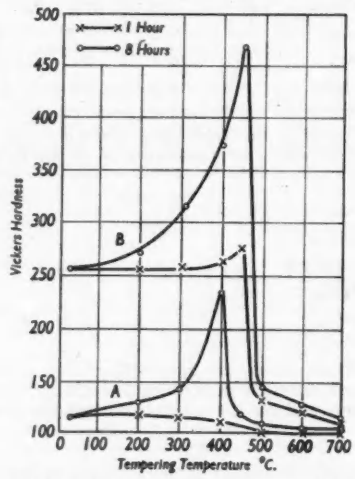


Fig. 1—Effect of Tempering for 1 Hour and 8 Hours on (a) Soft-Annealed and (b) Cold-Rolled 50 per cent Copper-Manganese-Nickel Alloy, 60 : 20 : 20 (Dahl and Dreyer).

Cent. for either 1 or 8 hours, hardness-tested and examined microscopically. The results of hardness tests are shown in Fig. 1. The authors conclude that there is an "incubation period" of unusually long duration, at least one hour, in both the annealed and the cold-worked alloy. They call attention to the fact that, whereas in most temper-hardening alloys the hardness falls gradually after passing the maximum, in the copper-manganese-nickel alloys the drop is steep and they speculate on the causes of this difference. Actually the general mechanism of the hardening process in these alloys, involving the formation of an ordered lattice structure rather than a precipitation, was explained in 1949 by C. H. Samans and others[5], who, incidentally, found (in agreement with the results shown in Fig. 1) that the maximum rate of hardening occurred at 370 deg. Cent. after softening but at an appreciably higher temperature after cold-working, e.g. 400 deg. to 480 deg. Cent., depending on the amount of cold work. There is nothing novel in Dahl and Dreyer's paper, which is referred to because of the interest of the hardness curves with their sudden fall from the maximum; but they deal, in effect, only with one time (8 hours) and one softening treatment. The subject is treated in much greater detail by R. S. Dean in his recently published book[6]. So far as it goes, the German work confirms the data given by Dean, who also shows the effect of different softening treatments, and of prolonged tempering treatments at 400 deg. Cent., in which hardness is continuing to rise after 56 hours. He also indicates the range of tensile and other properties attainable.

MECHANISM OF HARDENING

An understanding of the mechanism of hardening of these alloys is of practical importance as a basis for their commercial treatment. In typical dispersion hardening the effect of increased reheating temperature is first to produce hardening by precipitation of very fine particles, then over-ageing with considerable softening by agglomeration of the precipitate into coarser particles and, finally, solution. Over-ageing can only be remedied by re-solution and application of the correct ageing treatment. In the copper-manganese-nickel alloys, however, any softening is due to solution and the alloy can be rehardened directly by simply heating it again to the hardening temperature. Substantially complete softening is achieved after one hour at or above 540 deg. Cent. and even after incomplete softening at 510 deg. Cent. the alloy may be completely rehardened by heating at 400 deg. Cent. The following figures for Vickers Diamond Hardness are given by Dean :—

	510 deg. Cent.	540 deg. Cent.
After 4 hours at ... ... Hardness	212	130
Reheated 10 hours at 400 deg. Cent. Hardness	430	410

The most probable explanation is that the hardening is not due to a disperse phase but to ordering. Consequently any softening due to disorder can be counteracted simply by reheating in the temperature range for ordering. This mechanism also explains why these alloys harden so slowly, requiring many hours to reach maximum hardness, but soften almost instantaneously on being heated above the hardening temperature. This slow attainment of hardness permits control of the properties of the alloy. The sluggishness of the ordering process also enables the alloy to be hardened by isothermal treatment in the hardening range during cooling from the softening temperature.

REFERENCES

[1] *Trans. Amer. Soc. Metals*, 1941, Vol. 29, page 808.
[2] *Trans. Amer. Soc. Metals*, 1945, Vol. 34, page 481.
[3] *B.P.*, 658,264.
[4] *Metall*, December, 1952, page 753.
[5] *Trans. Amer. Soc. Metals*, 1949, Vol. 41, page 961.
[6] "Electrolytic Manganese and its Alloys," New York: Ronald Press Company. 1952, pages 125–153.

Is Chromium Inherently Brittle?

THE limited usefulness of chromium-rich alloys, in spite of their high resistance to oxidation and their strength at high temperatures, is due to the fact that they are so brittle at room temperature as to cause difficulty in machining and handling, and show a very low resistance to thermal shock. The question has been raised as to whether brittleness is an inherent property of chromium, or whether it is possible to obtain metallic chromium in a ductile condition. Much work has been done on the subject mainly at the Battelle Memorial Institute in America and at the Fulmer Institute in this country. At the Symposium on High-Temperature Steels and Alloys, held by the Iron and Steel Institute in 1951, Mr. Howard Cross, of the Battelle Memorial Institute, gave some information about results they had obtained which encouraged the belief that plastic deformation was possible in chromium of sufficiently high purity. A more detailed account of the research on this subject at Battelle has now been published by H. B. Goodwin, R. A. Gilbert, C. M. Schwartz and C. T. Greenidge in the form of an interim report.* In approaching the subject, they were encouraged in the belief that the brittleness might be overcome by the fact that molybdenum, vanadium, zirconium and titanium, at one time all thought to be brittle, have now been obtained in a ductile condition. The study at Battelle has been directed to the production of chromium of the highest possible purity by some ten different processes, of which the iodide process gave the purest material so far obtained. The chromium was in the form of tiny individual crystals. A light blow would shatter one of them, but it could be reduced in thickness by 35 or 40 per cent by slow compression applied at the rate of 0·05in per minute. With higher rates of deformation, cracking occurred at less than 10 per cent reduction. To test the material in larger

* *Journal of the Electrochemical Society*, March, 1953, page 107.

* *Journal of the Electrochemical Society*, April, 1953, page 152.

bulk, several buttons were prepared by arc melting some of the crystals on a water-cooled hearth in argon. One button was rolled to a strip, 6in long, ¼in wide and 0·05in thick. Its Vickers hardness was 210 compared with 125 to 148 for the crystals. This rolled strip could be bent elastically, but would withstand no plastic deformation whatever. It failed in a brittle manner with no measurable elongation at 46,000 lb per square inch even when the rate of straining was only 0·001in per minute.

Several crystals were heated in purified argon at 1620 deg. Cent. for one hour and quenched in mercury in an attempt to put any impurities into solution or into an evenly dispersed form. These heat-treated crystals could be strained to a greater extent and at higher rates than the untreated crystals, e.g. in one case, 75 per cent reduction in thickness with only small edge-cracks with a rate of strain of 0·15in per minute. There was micrographic and electron-micrographic evidence of slip lines, slip occurring on the (110) planes as in some other body-centred cubic metals, including molybdenum.

The evidence supplied by this work favours the "impurity" theory of the brittleness of chromium and suggests that the production of ductile chromium may not be an impossibility. Even if this result is achieved, however, the difficulty of retaining the metal in a ductile condition (as exemplified by the behaviour of strip, mentioned above) is an indication of the obstacles that would have to be overcome in the commercial production of ductile chromium-rich alloys.

Recent Developments in Hard Metals

MANUFACTURERS of sintered hard metals have accumulated a great amount of experience relating mainly to particular raw materials and plant which are used. There is, however, a growing need for more fundamental knowledge of the whole process of manufacture of these hard alloys, and the trend in this direction is ably summarised by Dr. E. J. Sandford, of Hard Metal Tools, Ltd., Coventry, in a paper which appears in the *Alloy Metals Review* for March, 1953. The recent work of Rautala and Norton on the constitution of the tungsten-carbon-cobalt system is summarised and also that of Gurland and Norton on the role of the binder phase. This provided evidence of the non-existence of a continuous skeleton of tungsten carbide and of the cementing action of the cobalt. The high transverse strength of these alloys is attributed to the high elastic modulus and yield strength of tungsten carbide which prevent the cobalt from yielding. The strength at first increases with increase of cobalt content (i.e. with increase of the thickness of the film of cobalt), but reaches a maximum at about 20 per cent.

Attention is directed to the work of Trent on the efficiency of titanium carbide in preventing the breakdown by "cratering" of tungsten carbide tool tips. Careful microscopical examination revealed that when alloys of tungsten and cobalt are used for machining steel, a fused layer of iron and tungsten carbide is formed behind the cutting edge, and solution of carbide takes place easily producing the well-known crater. When titanium carbide (for example, 15 per cent) is added to the tool tip, the grains of tungsten-titanium carbide solid solution are not dissolved in these circumstances, or at any rate only slowly.

The greater part of the output of sintered hard metals is still produced by cold-pressing and sintering. Hot-pressing in graphite moulds is used for large pieces and in some cases for drawing dies. There seems, in Dr. Sandford's opinion, to be no justification for the statement that the quality of hot-pressed hard metal is better than that of cold-pressed and sintered alloys, but theoretical and practical aspects of the subject are discussed. The hot-pressing technique can be used with advantage to reclaim large and expensive dies which have worn oversize in the bore.

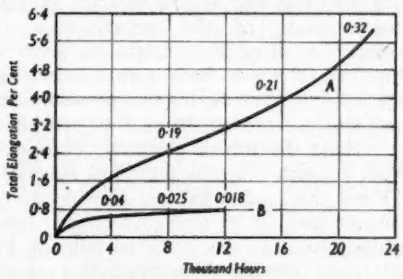
The production of sound compacts by cold-pressing and sintering tungsten carbide without a binder is scarcely possible because there are no liquid-solid surface tension forces to produce contraction. It has been shown, however, by A. E. Williams that pure tungsten carbide of grain size less than 1 micron can be hot-pressed at 1650 deg. Cent. to give high densities and a transverse strength of 75,000 lb per square inch. Interesting questions of grain growth, which need further investigation, are raised by these experiments. The production of hard metal compacts by impregnation technique has been the subject of experiment. Kieffer and Kolbl prepared compacts of tungsten carbide (WC) and of a WC-TiC solid solution by pressing and sintering at 1500 deg. Cent. The compacts were then impregnated with cobalt or with alloys of cobalt and tungsten carbide at 1450 deg. Cent. Sound structures were obtained only when the final impregnated compact contained 15 per cent of cobalt. The method appeared to have no application for producing normal grades of hard metals with, for example, 8 per cent of cobalt.

Recently, some details have appeared of a new process, developed by the Linde Air Products Company, of New York, and called by them "flame plating." The process appears to be akin to metallising. Thin coatings of a deposit of tungsten carbide and 8 per cent cobalt may be applied to all types of steel, cast iron, aluminium, copper, brass, bronze, titanium and magnesium, but not to chromium plate or sintered tungsten carbide. No alloying takes place between the base metal and the deposit, and the temperature of the base metal is said not to exceed 200 deg. Cent.

Dr. Sandford's article contains further discussion of many of the points outlined above, together with full reference to the original sources of information.

Warm-Working of a High Temperature Alloy

WARM-WORKING of high-temperature alloys, first applied successfully by William Jessop and Sons, Ltd., to gas turbine discs of G18B, is, as might be expected, receiving other applications. It is a method which should be applicable to all types of steel. Use of the process by the Timken Roller Bearing Company is described by M. Fleischmann.* The Timken alloy known as 16–25–6, containing chromium, nickel and molybdenum in these approximate proportions with a maximum carbon content of 0·12 per cent, was widely used in the U.S.A. during the war in gas turbines and turbo-superchargers and is now finding a wider application in jet engine turbine wheels, with probable extension of its use in stationary power units. Details are recorded of the properties of the material after water quenching from 1175 deg. Cent., giving solution of the carbides and minimum hardness, and in the form of hot-rolled 1in diameter bars which had been further reduced 25 per cent by finish



A—Solution quenched from 1175 deg. Cent.
B—Hot rolled, then finish rolled at 815 deg. Cent. and tempered at 690 deg. Cent. for six hours.
The figures on the curves are creep rates per cent per 1000 hours

Fig. 1—Creep Tests on 16–25–6 Alloy Under Stress of 8·9 Tons Per Square Inch at 650 Deg. Cent.

rolling at 815 deg. Cent. The process is referred to as "hot-cold" work; the term warm-working is used only once in the article. Finish rolling in this temperature range resulted in considerable cold work. Subsequent tempering for six hours at 690 deg. Cent. relieved stresses without materially affecting the hardness. Room temperature tests of the material in both conditions are given in the table. They represent minimum and maximum values. Intermediate properties may be specified and are produced by varying the reduction in warm working and so varying the amount of cold work introduced into the material. Creep tests confirmed the beneficial effect of the hot-cold working treatment. Tests at 650 deg. Cent. and 705 deg. Cent. of at least 10,000 hours' duration were made, and the results given in a number of curves which showed that, at least up to 705 deg. Cent., total deformation under a given stress may be materially reduced by the hot-cold working of the alloy. This superiority over the solution-quenched alloy was not retained at 760 deg. Cent. Two of the curves are reproduced in Figs. 1 and 2. With a stress of 8·9 tons per square inch at 650 deg. Cent. (Fig. 1) both the total deformation and the creep rate of the solution-treated alloy were many times those of the hot-cold-worked specimen, especially after long-time tests. At 705 deg. Cent. with a stress of 5·6 tons per square inch (Fig. 2) almost identical creep rates

* *Iron Age*, November 20, 1952, page 123.

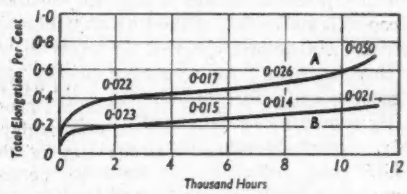
Mechanical Properties of 16–25–6 Alloy

Heat-treatment	Solution-quenched, 1175 deg. Cent.	Hot-rolled, followed by rolling at 815 deg. Cent., tempered 690 deg. Cent. six hours
Limit of proportionality, tons per square inch	11·1	33·5
Yield strength, 0·1 per cent, tons per square inch	21·6	52·2
Yield strength, 0·2 per cent, tons per square inch	22·8	53·6
Tensile strength, tons per square inch	52·7	67·0
Elongation on 2in, per cent ...	46·0	18·0
Reduction of area, per cent ...	64·8	32·0
Brinell hardness number	188	302/321

were observed for the alloy in the two conditions between 2000 and 6000 hours, although the total deformation of the solution-treated alloy was about twice as great as that of the hot-cold-worked alloy.

Tests to fracture indicated that elongation at fracture decreased as rupture time was extended, but superior ductility was shown by the hot-cold-worked material.

An outstanding development in jet engine design is the composite turbine wheel in which a highly alloyed rim is welded to a low alloy hub. Owing to its excellent weldability and desirable high-temperature properties, the 16–25–6 alloy has been selected as the rim material in one design and the nickel-chromium-molybdenum steel SAE 4340 (Cr 0·5/0·8, Ni 1·5/2·0, Mo 0·3/0·4 per cent) is employed for the hub, where its properties as heat-treated are used advan-



Conditions *A* and *B* as in Fig. 1.
The figures on the curves are creep rates per cent per 1000 hours.

Fig. 2—Creep Tests on 16–25–6 Alloy Under a Stress of 5·6 Tons Per Square Inch at 705 Deg. Cent.

tageously at the relatively low operating temperature of the wheel centre. To obtain the highest room temperature properties as well as the minimum creep in operation during the expected life of the jet engine turbine wheel, the 16–25–6 alloy rim has to be warm worked. Up to the present this has been accomplished by working the forged rims at 650 deg. Cent. to 700 deg. Cent. Very large hammers were required for this warm-working operation, and control of the end point, which determines the final mechanical properties, especially ductility, was difficult to maintain.

A new method of expanding turbine wheel rims (subject to a patent application) has been developed by the Timken Company, not requiring large hammers and likely to produce a more uniform product. The rim is hot forged about 20 per cent smaller in o.d. and 30 per cent smaller in i.d. than the desired final dimensions. It is machined concentrically and subsequently expanded in three consecutive steps in a special die, the main features of which are indicated in the article. The hardness of the alloy is thus raised from 187 to 269. The rim is then tempered at 705 deg. Cent. for twelve hours to relieve stress and equalise hardness variations. The method is only applicable to austenitic materials.

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CHIEF JOSEPH DAM

A recent event in America has shaken confidence in this country and, indeed, in the world at large that Americans really understand the strength of the need of other nations for "trade, not aid." That event, of course, was the recent refusal of the tender of the English Electric Export and Trading Company, Ltd., for transformers and generators at the Chief Joseph dam in Washington, despite the facts that the lowest American bid at 7,170,000 dollars is reported to have been well above that of the English company at 6,238,000 dollars, and that the terms of the "Buy American" Act would not have barred acceptance of a foreign bid. On April 22nd, after rumours had circulated for some days, Mr. Robert Stevens, the Secretary of the U.S. Army, officially justified the action, now being taken, of rejecting all tenders and getting out new specifications, by stating that there were discrepancies in the "copper content" of the American and British tenders. But it cannot be overlooked in this country that one of the results of sending out new specifications and calling for new tenders may be to prejudice the renewed success of the British company as against its American competitors. Moreover, it seems a very remarkable thing that the original specification could be so drawn up that significant discrepancies could arise. In the United States itself the question is being asked why, if that discrepancy was the real reason for the rejection of the tenders, it should have been necessary to refer the matter to at least one meeting of the American Cabinet. A strong impression is conveyed that the tenders have all been rejected because the British tender was the lowest!

As an isolated decision that upon the Chief Joseph dam contract does not seem, however, as significant as comment about it would suggest and it seems all the less important in that at a second attempt the British company may still turn out to be as successful as at the first. What gives it a possibly spurious significance is that a number of similar contracts have recently been secured by British firms which were therefore growing more confident of their ability to penetrate the American market in despite of customs duties and the "Buy American" Act, thus, perhaps, arousing fears amongst American makers of the loss of a part of their home market; and that an apparent reversal of American trading policy has coincided with the advent of a "Republican" administration. There is a suggestion, as Mr. Peter Thorneycroft put it in the recent debate on the Budget in the House of Commons, that "the treatment and outcome of this case" may be "in some way a pointer to the future commercial policy of the American Administration." The action over the Chief Joseph dam contract, in fact, arouses fears of the recrudescence in America of harsher protectionist policies. But even if those fears may in part be justified, it is worth noting that protectionists have still not proved strong enough wholly to exclude the British products concerned. Wiser counsels may still prevail in America.

Fears that under its new administration America may prove more protectionist than before may also be partially relieved by observing how the American action under discussion has not openly been made for protectionist reasons. Blunt protectionist decisions announced as such would unquestionably have been deplored and resented here. But they would have been well understood. For all manufacturers can sympathise with others who see their home markets penetrated by oversea competition! In fact, however, not so much a reason as an excuse has been offered, an excuse that sounds, apparently as unreal to some American ears as to British ones. The *New York Times*, for instance, has remarked of the tenders for the dam contract that the reason offered for their rejection "gives our country's words a hollow ring," and a number of American journals have not hesitated to criticise the Administration for its part in the affair. Bluntly protectionist decisions, it may be hazarded, would not have been acceptable to a large part of the American public. It is true that there is far less appreciation in the industrial mid-West of the United States of the realities of international economics and the necessity for a creditor nation to accept imports than there is in New York, Washington and other cities of the eastern seaboard. But America has not yet returned to the protectionist policies that the Democratic Administration relaxed, and opposition to such a course still remains strong. Patience may therefore yet see the Chief Joseph dam contract in British hands. We hope it will. For it would be a tragedy for the Western World if, instead of further relaxing protectionist policies, the United States were to make them tighter. The American administration, which is so much better informed than mid-West industrialists, can hardly be unaware of it.

INDUSTRIAL GAS TURBINES AND RESIDUAL FUELS

The problems which beset the development of industrial gas turbines seem inexhaustible. As a means of converting heat energy into power no other prime mover ever promised such simplicity. Yet the simplicity has proved deceptive. Experience has revealed a whole series of technical difficulties that have needed and still need to be overcome. There were, firstly, aerodynamic ones. Some of them centred around the controversy about the relative advantages of centrifugal and axial compression; and even if that controversy may now be said to have been settled in favour—temporarily, perhaps—of the axial, it served in its time to startle many by revealing the enormous blade production problems involved. Manifest, too, from the first, were the dynamic and aerodynamic loading problems of the blading. More ominous, owing to the temperatures involved, were the possibilities of trouble from creep, a phenomenon, until well understood, which has about it the distastefulness of a malignant growth. Nor are fatigue problems unknown to those engaged on gas turbine development. But when Whittle and his associates were bringing the "jet" gas turbine to fruition none of those problems was wholly new. They had already been encountered in steam turbine work and elsewhere, though not in such extreme forms. Fortunately, other troubles which were to beset the development of industrial gas turbines still remained to be revealed; otherwise jet-propelled aircraft might hardly yet have been flying. For the gas turbine has not the overwhelming advantages on the land and at sea that it has in the air and if its early promise of challenging existing prime movers is to survive, it must, in particular, prove able to digest a cheaper fuel-oil than that used in aircraft and possess a life at least comparable with that of other engines.

It is in the use of residual fuels that serious difficulties have been encountered. For ash deposition and its more evil associate, corrosion, have played havoc with blade efficiencies. No such serious snag has been met in diesel engines burning similar fuels. The whole fascinating story of how this particular difficulty was evaded rather than

overcome is told in the paper we reproduce elsewhere in this issue. It appears that just as traces of impurities can be the nurturing agents of fatigue and creep, so did these ash problems result directly from the influence of trace elements in the fuel, amongst them the now notorious vanadium metal. Nature, it seems, prepared this difficulty with infinite care over ageless years. For the authors state how it is now generally accepted that these trace elements are derived from the animal or vegetable remains from which the petroleum is formed—bones yield calcium, seaweed yields nickel, certain crustaceans and molluscs contribute zinc, and other marine creatures such as sea squirts provide vanadium. Supporting this belief is the fact that one of the soluble organic-metallic compounds which has already been observed in oil—known as vanadium porphyrin—is stated to be similar to the complexes of hæmatin and chlorophyll, the colouring matter of blood and plant. Of the many compounds forming possible ash constituents, most have melting points above current industrial gas turbine temperatures. The principal exceptions are the sodium sulphates and some compounds of vanadium ; and it is suspected that certain unidentified trace elements are also involved. These molten compounds, being sticky, adhere to the blades and have a fly-paper action on other dry ash particles, causing loss of performance due to blockage. Much worse, they harbour the corrosive constituents. Thus is an unholy alliance created. The effectiveness of known or applicable methods of removing the ash forming constituents could hardly have appeared more discouraging when the situation first revealed itself. Centrifuging and filtration were only applicable to inorganic insoluble material and therefore the soluble metallic compounds in which form the vanadium pentoxide is thought to exist remained unaffected. Methods of employing solvent or distillation processes proved so expensive that they would have destroyed the price differential between a distillate and a residual fuel. According to the authors, removal of the ash after combustion was no more acceptable—centrifuging by the use of cyclone separators or filtration through refractory pebble beds was not sufficiently effective. That, however, was a view challenged by at least one contributor to the discussion. The method of electrostatic precipitation, even if it could be applied, would, according to the authors, be very expensive. The only other object at which to aim was to minimise the deleterious effects of the ash *en passant*. Fortuitously—how often it happens, when people persevere, that chance offers a clue !—a solution within the temperatures under investigation was obtained. It was observed that when combustion of the carbon was very slightly incomplete and when, therefore, minute carbon particles formed, they acted as nuclei to collect a considerable portion of the ash and as absorbents of certain noxious fluids and vapours. Having done so, and being roughly spherical, hard and dry solids, they were able to pass through the blading without deposition. They did, however, introduce the possibility of abrasion. The degree of under-combustion needed was very simply obtained by adjusting the atomisation particle size, with an almost negligible effect on the overall combustion efficiency. A very different approach to this problem of deposition has been the use of additions in the fuel, although their action is not fully understood. Silicon has proved the more effective of these additives, and it is suggested that silicon oxide in some way inhibits the formation of low melting point sodium sulphates. Thus—particularly if these two solutions to the problem are used simultaneously—the authors conclude that the gas turbine can be largely freed from the penalties of burning residual fuels, for they believe that if deposition can be avoided, the more serious forms of corrosion will also be inhibited.

It is improbable that the solution to the problem is complete, great though the advance may well prove to be. Solutions seldom are complete in engineering practice. The authors, probably, " have scotched the snake, not killed it." It was, for instance, pointed out in the discussion that with turbine inlet temperatures little higher than the 565 deg. Cent. used, vanadium pentoxide and eutectic mixtures of this compound with sodium oxides remain molten, and corrosion may still assume major proportions. Moreover, the gas turbine, if it is to compete effectively with other prime movers, will need to be developed in the future to run at still higher temperatures. At those higher temperatures lie the melting points of a host of other ash producing constituents. What unpleasantness may they yet introduce ? Or will they likewise be induced to pass harmlessly through all the stages of the turbine, using the solution described in the paper ? We cannot know. In the immortal words of Mr. Asquith we shall need to " wait and see."

Obituary

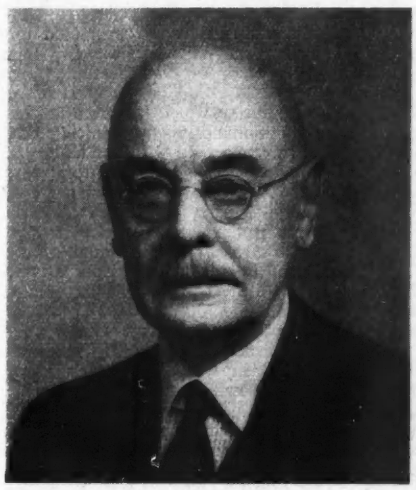
JOHN HALL RIDER

We regret to record the death of Mr. John Hall Rider, at "Sleepy Hollow," Woldingham, on Thursday, April 23rd. Mr. Hall, who was in his ninetieth year, began his career in the early days of electricity generation and distribution and electric traction in Great Britain : he lived to see the country's electricity generation and transmission system grow into the largest integrated system of its kind in the world and he also saw the rise and decline of electric tramways. For the greater part of his working life he was a partner in the firm of Preece, Cardew and Rider.

John Hall Rider was born in Bristol on January 30, 1864, and in 1880 he began to study electricity and magnetism under Dr. Cook at the Bristol Trade and Mining Schools. In 1883 he was apprenticed to Messrs. Paterson and Cooper, and while he was with the firm he carried out a number of lighting contracts in England and Norway. Four years later he joined Blakey, Emmott and Co., Ltd., of Halifax, as the firm's electrical engineer, and became responsible for the design and manufacture of its dynamos and lighting plant. In 1893 he was appointed borough electrical engineer to the Corporation of Bolton and he was responsible for the borough's electric lighting undertaking. After three years he left Bolton to become borough electrical engineer to the Corporation of Plymouth, where he designed combined works for electric lighting and traction and superintended their construction.

Further experience in traction came his way when, early in 1901, he was appointed electrical tramways engineer to the London County Council. In that capacity he was concerned with electrification of the L.C.C. horse-drawn tramways, mainly on the underground conduit system. Before his death the whole of this tramway system had given place to omnibuses. The Kingsway tram subway, now closed, was the direct outcome of a visit to North America in 1901 to study and report on shallow underground tramways. Another of his responsibilities was the L.C.C. generating station at Greenwich, which, together with a number of substations, was built to his designs.

Ten years' service with the L.C.C. ended in 1910, when he was appointed chief electrical and mechanical engineer to the Central Mining and Investment Corporation, Ltd,



J. H. Rider

and the work he carried out for that organisation was the subject of a paper before the Institution of Electrical Engineers in 1915.

In that year there began an association which lasted for the rest of his life : on returning to England from South Africa he became a partner in the firm Preece, Cardew and Snell, and the title of the firm was accordingly changed to Preece, Cardew, Snell and Rider. His first major work with the firm concerned the new Harbour power station at Belfast. Most of the work had been done by the late Sir John Snell, but when he was appointed Chief Electricity Commissioner and resigned his partnership in the firm Mr. Rider took over the completion of the work. Later he designed the new power stations at Nottingham, Norwich and Swansea. At the same time he was occupied with a survey of electricity supply in London, on behalf of the London and Home Counties Joint Electricity Authority, as a result of which plans were drawn up for building a major power station in the western part of the area. Accordingly, in association with the late Mr. A. J. Fuller, he designed Fulham power station, which has a capacity of 310MW. The last major installation with which he was concerned was the new Kingston power station, which was the first station to be opened after nationalisation of the electricity supply industry and now has a total installed capacity of 123MW.

Mr. Rider was a member of the three major engineering institutions. In 1909 he was elected to the Council of the Institution of Electrical Engineers and the next year he was elected a vice-president. He was also a past-president of the Incorporated Municipal Electrical Association, an association which was founded largely on his initiative in 1895.

The Dilemma of Lord Kelvin

AT a meeting of the Institution of Electrical Engineers on Thursday, April 23rd, the forty-fourth Kelvin Lecture was delivered by Professor P. I. Dee, who is the Professor of Natural Philosophy at Glasgow University, where he occupies the Kelvin Chair. Before the lecture the president of the Institution, Colonel B. H. Leeson, presented the I.E.E. certificate of honorary membership to Sir Harry Railing for his services to the electrical engineering profession and to the Institution. The president then presented the Faraday Medal to Colonel Sir A. Stanley Angwin, for his outstanding contributions to the development of communications in Great Britain and internationally.

In his lecture, which was entitled "The Dilemma of Lord Kelvin," Professor Dee sought to show how, as Kelvin's career progressed, he was faced with the choice between the pursuit of pure science and of its applications. Professor Dee reminded his audience that William Thompson, later Lord Kelvin, entered Glasgow University at what would now be considered the tender age of ten years. When he was twenty-four he accepted the Chair of Natural Philosophy at Glasgow University, and he occupied it for fifty-three years, during which he wrote no less than 661 papers. Some of his first philosophical speculations were concerned with the nature of electric fields and suggested that, seventeen years before Clerk Maxwell, he was within sight of Maxwell's theory. However, Thompson's early work was mainly in the field of thermodynamics, and it was in 1851 that he presented to the Royal Society of Edinburgh his paper on the dynamical theory of heat in which he reconciled the work of Carnot and Joule and established the second law of thermodynamics.

In 1853 he published his paper "On Transient Electric Circuits," in which he foreshadowed the discoveries of Hertz some thirty-four years later. It was this side of Kelvin's work which drew him towards the application of electricity to submarine telegraphy, which brought him his greatest renown, and which posed what Professor Dee called Kelvin's dilemma. When Kelvin became a director of the Atlantic Telegraph Company he soon found himself grappling with the practical problems of laying and putting into service the transatlantic telegraph cable. He had already propounded the mathematical theory of submarine cable signalling and reached the conclusion that the attenuation caused by capacitance made the speed of signalling inversely proportional to the length of the cable. He persuaded his associates, not without difficulty, of the importance of resistance, and with characteristic energy and resourcefulness he set out to specify and produce copper of uniformly high conductivity. He also devised sensitive apparatus to detect minute variations of current, and his work resulted in the development of the mirror galvanometer and siphon recorder.

Books Received

High Voltage A.C. Circuit Breakers. By S. Gerszonowicz. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 63s.

Visual Lines. By D. M. Smith. Second edition. London: Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, N.W.1. Price 16s.

Historical Metrology. By A. E. Berriman. London: J. M. Dent and Sons, Ltd., Aldine House, 10–13, Bedford Street, W.C.2. Price 16s.

Transmission Lines and A.C. Networks. By T. F. Wall. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 30s.

Cathode-Ray Oscillograph in Industry. By W. Wilson. Fourth edition. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

The High-Speed Internal Combustion Engine. By Sir Harry R. Ricardo. Glasgow: Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 40s.

Radio and Radar Technique. By A. T. Starr. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 75s.

General Degree Physics: Part I, General Properties of Matter. By C. J. Smith. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 50s.

Physical Metallurgy for Engineers. By Donald S. Clark and Wilbur R. Varney. London: MacMillan and Co., Ltd., St. Martin's Street, W.C.2. Price 45s.

The British Electricity System

No. I

Early last year a team of seventeen men from the U.S. electric utility industry visited Great Britain under the auspices of the Anglo-American Council on Productivity, to make a field survey of the British Electricity supply system. Its report was published this week (price 3s.) by the British Productivity Council, 21, Tothill Street, S.W.1. Abstracts from the report are reproduced herewith.

MANY of the differences between British and American power plant practices have already been stated in the Productivity Report on Electricity Supply, 1950, published after the visit of the British teams to the U.S. Some of these differences are summarised as follows.

There is a much longer time required between the original promotion of a new plant and its going into operation. Prior to the present armament programme in the U.S., approximately twenty-eight to thirty months were generally sufficient to buy and install new turbo-generators and boilers in America. Three years are now required. Contrasted with this schedule, British post-war experience has ranged from five to seven years. An understanding and knowledge of differences in conditions, however, somewhat account for the variation. Britain has been more severely limited by shortages in materials and by inability to get skilled construction man-power at new plant locations. However, the time required to get approval for use of proposed sites for generating stations and acceptance of basic designs from the many ministries and semi-public groups involved accounts for the biggest delay. Three to four years are often so required, and detailed drawings of the proposed plant and its equipment are required for hearings and approvals. Thus, in addition to delay in obtaining needed capacity, a considerable amount of obsolescence may be frozen into plant designs long before the actual placement of equipment contracts. The matter of obtaining approvals is one that should be facilitated.

There is a considerable difference in size between British and American units now going into service, as well as those now being considered for new plants. Whereas many 125MW to 175MW units in the U.S. are now coming into service, and 100MW is being typically installed by middle-sized utilities, most new 1952 British units are 30–50MW, and only a few 100MW turbines are planned for 1956–57 plants. In the U.S. 250MW tandem compound reheat units are being offered for 1955 installation. A size difference of roughly three to one seems to be broadly the rule. American experience has shown that there is a 25 per cent saving in material and construction cost of a generating plant by doubling the capacity of a unit (as 60MW to 120MW), and a 40 per cent saving when the size is tripled. This fact warrants consideration in present-day planning in Britain.

The British Midlands coal, with its high ash content and slagging tendencies, around which future plant designs are being made, is approached in quality by only the Illinois, Iowa and western Kentucky fields in the U.S. The quality of British coal which is to be available in the future is an unknown quantity. This is a matter of the utmost importance which the Coal Board should take immediate steps to resolve. Power plant designs are being based on coal with heat content as low as 9000 B.Th.U. per pound and 22 per cent ash content, whereas 11,000 B.Th.U. per pound coal could be readily assured by modern coal preparation plants at the mines. With pulverised fuel firing, low coal quality has been regarded by designers in both countries as having limited dependable boiler sizes to 100MW in recent years and to about 60MW prior to 1947. The absence of a free market in coal of the quality for power stations, at the same time as a shortage of mined coal, clouds the economics of this situation. An early compromise as to future steam coal quality and pricing for B.E.A. purposes is urgently needed. It will also be imperative that sufficient mined coal be available to meet increased generating power needs. As long as these matters remain in doubt the designer is working under a crippling handicap.

Steam pressures and temperatures are lower in British practice than in American. The need for quickly available and proven designs in Britain led, broadly speaking, to standardisation of 30MW machines at 650 lb per square inch, 850 deg. Fah., and of 60MW machines at 900 lb per square inch, 900 deg. Fah., in the years 1945 to 1952, and 1500 lb per square inch, 1050 deg. Fah., generally without re-heat, as the best for 1957 plants. Typical units now going into service in America call for the latter condition plus re-heat, and higher steam conditions are being planned for the time when alloying metals are freed from control.

Instrumentation generally has not been utilised as much in Britain as in the U.S., and no plans have been completed in Britain for compact integrated boiler-turbine-electrical control rooms now typical in new U.S. plants.

Size of Units

The new steam plants now being commissioned in Britain give an impression of large building bulk for the capacity contained. Plants in excess of 50 cubic feet per kilowatt are common, compared with less than 30 for new American plants, and with about the same for British plants now under design and scheduled for commissioning in 1955–57. This bulk stems, first of all from the smaller rating of turbines, and from the frequent use of spare boilers or two boilers per turbine. Until recently, also, British turbines for equal capacity have been greater in overall length than American units. A 60MW unit with exciter is usually about 95ft in length, compared with the same length for 100MW and with 105ft for 140MW units in American practice. The typical turbine now being installed is a 60MW unit, whereas in America even middle-sized power systems had adopted 100MW units for 1952 commissioning, and units of 100MW to 175MW are now common in larger systems. One 105MW unit was commissioned at Battersea in 1935 and a 100MW cross-compound unit has since been commissioned, and this latter size has been adopted for a few of the new plant extensions, particularly those to be installed in connection with the new 275kV grid in the Midlands area. At the same time, American practice appears to be headed for units in excess of 200MW.

Partly because 3000 r.p.m. is the top 50-cycle speed, permitting longer blades than in American practice of 60-cycle, and because of lower megawatt ratings, British practice tends to single-shaft turbo-generators. Installations arranged both across the turbine room and lengthwise have been used. The predominant use of the lengthwise plan would necessitate a longer turbine room.

Boiler size shows even greater contrast. In American practice a single boiler per turbine, even for units of 125MW to 200MW, using low-grade slagging coal, has become quite standard for 1952 commissioning. An appreciable number of British 60MW units now going into service have two boilers, and one major new plant (for Glasgow) has two boilers for one 50MW turbine being commissioned this year. In the past there has been ample evidence in both countries that boiler size with pulverised fuel firing has been severely limited by coal quality. Until three or four years ago in America it appeared that for high-ash coal with 1900 deg. Fah. fusion temperature boilers could not be satisfactorily designed for much over 60MW (550,000 lb steam per hour). Above this size severe slagging developed on the side walls and in the boiler and superheater tubes, causing costly outages for cleaning, and requiring high amounts of excess air. Attention can now be directed, however, to American pulverised fuel fired boilers of 120MW in successful operation on 16 per cent ash coal, fusing at 1900 deg. to 2000 deg.

Fah.; single boilers for 180MW turbines and with such coal will soon be in service and even larger units have been designed.

Plant Dimensions

While there is little difference, particularly in plant length, between British plants such as Castle Donington, planned for 1956, and a typical American plant of 1952, also burning low-quality coal, British plants being installed this year bulk much larger than contemporary U.S. plants. Four factors are responsible: (*a*) more generous aisles and use of bays with separate travelling cranes for access to main and to auxiliary equipment; (*b*) low kilowatt rating of turbines; (*c*) use of spare or multiple boilers for one turbine; and (*d*) greater length of tandem compound turbo-generators in Britain. All four of these factors, which add substantially to building costs and use of scarce materials, may be corrected by design studies. While generous aisles and cranes assist in plant maintenance, most studies indicate that full use of space can be coped with by careful placing of equipment, overhead hoist rails, floor rails for pulling bundles or shells from horizontal heaters, framing for slings and swing hoist hooks, and by the use of movable power-operated lift trucks which have been developed for storing materials.

Part of the British hesitancy to install large single boilers per turbine unit comes from a record of low boiler availability, being approximately 85 per cent. This problem is being carefully studied and improvements are being effected, a similar process of study in American by inter-company committees having effected improvements until boiler availability of over 95 per cent is now considered assured.

Control Panels

Single boiler-turbine designs at 100MW have been adopted for the new Midlands series of plants such as Castle Donington. Steam pressures and temperatures are also to be higher in these new plants, namely, 1500 lb per square inch and 1050 deg. Fah. The adoption of the unit system as well as high-temperature steam has led American practice to centralised control rooms from which, typically, a single boiler and turbine and station electrical system are controlled from a compact integrated control panel, the usual arrangement being a pair of such panels opposite one another in a single location controlling two units. Such unified control is considered advantageous not only from the standpoint of the number of attendants required but particularly for safety of equipment. In case of trouble on high-temperature units, it is essential that boiler and turbine operation be closely related. Any circumstances, such as loss of fires in the furnace, which will be followed by rapidly falling steam pressure and temperature must be accompanied by protective operation on the turbine within a few seconds to avoid temperature strains and consequent shaft bowing, rubbed seals, or warped casings. In such an emergency, communication by telephone or public address system is severely limiting and a common operator eliminates this step in the protection of men and equipment. Similarly, a temporary or minor loss of steam pressure, such as from the loss of one pulveriser, can be readily appraised, and drastic load-dropping be avoided.

Outdoor Installations

British practice is cautious in the use of outdoor installations of auxiliaries or boilers. One semi-outdoor boiler installation is to be made in a plant now being planned, but in present practice even draught fans and precipitators are usually housed in. Such practice is explained on two grounds; the damp climate and the habit of fine art commissions in insisting on exterior architectural beauty, to the extent that some outdoor auxiliary areas for ground level fans and precipitators have been screened by high ornamental brick walls. In one instance, such a wall screens the view from outdoor coal storage. It is difficult to translate American conditions and practice to a British environment, but a review of results with completely outdoor plants now going into service in the northern States should permit modification of 1956–58 British plants now being designed. In a country where snow is very infrequent, where total annual rainfall is generally less than in the eastern part of the U.S., and where the temperatures rarely fall below 20 deg. Fah., many more outdoor installations seem feasible. Trees and grass terraces have been used effectively in the U.S. to shield views and noise.

Building Materials

Building materials and interior trim in newer plants are usually of the highest grade and of fine appearance. In some plants this effect has been achieved at low cost by enlisting expert advice on industrial colour schemes devised for pleasing contrasts. American practice might well consider wider use of consultants for this purpose instead of leaving such decisions to plant personnel. Nevertheless, the time-lag between the conception of a new plant and its commissioning in Britain gives the impression that the new plants are not in keeping with austere times.

New designs call for galvestos walls, and it is assumed that the interior use of terrazzo, ornamental tile and marble will likewise decrease. Auxiliary buildings, such as those for offices, lockers, canteens and employee recreational rooms are generally extensive and handsome. A national law calling for a canteen in any establishment employing over 250 men means that some portion of such facilities will appear extensive even in future plants. Here the national food restrictions are a factor, as they necessitate the provision of higher protein meals at the plant for manual workers, the largest meal of the day being at noon.

The British are applying imagination in the construction of building walls and for fenestration. In one of the plants designed since vesting day (Doncaster New) a major portion of the sides of the building is of glass with aluminium frames. These panes of glass are approximately 5ft in height by 18in wide by $\frac{1}{16}$in in thickness. One man in a bosun's chair can install a row of glass from the top to the bottom in a very short time. A novel catch strip, inserted at one side after the glass is placed in the frame, holds it rigidly in position. This construction makes for a well-lighted, efficient wall at a cost very much less than that of brick.

The roof of this station is also of novel construction. An aluminium sheet, with a "V" formation each foot, is placed on steel beams and clamped to them. Over the aluminium sheet is placed impregnated felt approximately 1in thick. This felt comes in rolls about 4ft wide. The felt is fastened at intervals to the aluminium sheet and is then covered with tar paper with the seams sealed by means of pitch or tar. The construction of the roof and siding results in a building which should cost much less than one having standard siding and tile roofing. This new type of construction should prove effective in winds with speeds of up to 80 miles an hour.

Another interesting building development in British practice is the resort to reinforced concrete in monolithic form for turbine bay wall and roof, thus minimising the use of steel. There is also resourceful use of lightened steel plate for building up roof girders or columns. Also a greater portion of the typical turbine foundations is of concrete than in American practice. The British have fully developed movable form and concrete technique for cooling towers with considerable success. As noted elsewhere, concrete is used for fly ash precipitator housings.

Expediting

One substantial factor in the length of time taken for the erection of plant appears to be a lack of expediting and close scheduling of material and equipment deliveries. The American practice of bi-weekly checking at the manufacturers' plant on the status of major equipment does not appear to be followed. Many occasions were noted where the lack of one single item of material was holding up the job and causing workmen to be idle. By expediting fully such deliveries this situation could have been foreseen and corrective steps taken, or the construction schedule could have been altered to avoid loss of manpower.

Sites

The location of power plants in a single fully-integrated system should offer the greatest possible flexibility in the selection of sites economically and physically advantageous. These possibilities do not appear to have been completely realised in British practice. There are a number of essential requisites: (1) ample and economically available circulating water; (2) low fuel price; (3) avoidance of deterioration to surrounding property; (4) proximity to an available labour supply for construction and operating personnel; (5) foundation conditions; and (6) military security.

Time did not permit a true economic survey of these plant location factors. A few major impressions of the team, however, may be of value.

Coastal Sites.—Despite good cooling tower design, there is a distinct impression that the integrated British system could well abandon the inland river locations in favour of the estuaries and sea coast, where ample water is available. To the team the military objections of coastal vulnerability in these days of air warfare do not carry very much weight. Furthermore, the varied pressure groups who demand elaborate and rigid regulations on the interior rivers would not be concerned in much of the estuary area. Finally, it is admitted, most inland rivers are so small that soon they will fail to offer even sufficient cooling tower make-up water, and it will eventually be necessary to go to the coast, anyhow.

Water Haulage for Coal.—The selection of estuary or coastal areas for new power plants would appear to be supported by the low cost of coal haulage. Once coal is loaded in a ship or barge, haulage distance has less effect on cost than it has by rail. Finally, it has been concluded that it is more economical in the U.S. to haul coal to major power centres than to transmit power from the coal supply areas.

Steam Conditions

Re-heat cycles have been used only in a few instances, and only one major plant now being designed is so planned. American experience has demonstrated that re-heat involves no discernible complications of operation, and that it yields greater gains in economy than higher temperatures without re-heat. Hence, re-heat for new plants has become almost universal American practice during the past two years. Its wide use for British practice, where coal prices are relatively high and where annual fixed interest charges are low, is recommended by the U.S. team for consideration by the British Electricity Authority.

Stacks

An architectural feature of new plants in British practice has been the use of but one or two high masonry stacks for the whole station. Also a rule of two and a half times building height has been adopted, leading to stack heights of 350ft to 400ft. American practice varies as to stack height, but 300ft is probably closer to the average, and one or two boilers per stack is typical with units over 60MW. British stack costs are, therefore, higher because of height and the long runs of gas ducts involved. The ducts also add to maintenance costs and to cleaning problems for operators.

Two other American practices are suggested for consideration. Equivalent stack height without hazard to aviation is obtained with stack top nozzles giving gas velocities of 80–110ft per second. Generally this is equivalent to an extra 100ft of plume height in winds under 5 miles an hour. Secondly, the provision of means for heating air-to-air preheaters, or increasing stack gas exit temperatures, is typical as a protection against air heater corrosion or plugging in cold weather. The same devices can be used to increase stack temperature and add to gas buoyancy at times of atmospheric stagnation.

Turbine Designs

In the compact, now integrated, British system, covering an area smaller than the average American State, turbine sizes planned for the future appear surprisingly small. In sharp contrast is the present American practice for new units, which calls for 100MW size in practically all installations in heavy load areas where services are interconnected, and in which tandem compound units of 200MW are on order, and 250MW units are being offered. It is the recommendation of the U.S. team that far more 100MW units be planned for, and that even larger-sized units

be considered. The average turbine planned, but not yet built, to be installed in Britain up to 1956 could advantageously be increased from 30MW to 90MW, or 60MW to 180MW, assuming that adequately dependable turbine design and construction, and units compact as to overall length, could be offered by the manufacturers. The 50-cycle speed of 3000 r.p.m. should make this simpler than the 3600 r.p.m. needed for the American frequency of 60 cycles.

Trouble has developed on several of the high-pressure turbine spindles in Britain, requiring that they be sent back to the manufacturer for repairs, including heat-treatment of shafts. No single fault appears to be the cause, but frequently the trouble has occurred during either the starting or shutting down of the units. This could occur through the admission of too high a steam temperature on a cold turbine or cold steam on a hot turbine, or through reducing the steam temperature too quickly while reducing load. The long units, 90ft to 95ft on a triple tandem compound unit of 50–60MW size, require careful observation of the expansion of the turbine spindles and casings and an adequate number of thermo-couples and expansion gauges to help the operator to understand better the conditions of the various parts of the units. Every effort should be made by British turbine manufacturers to reduce the length of their machines, which in general are 40 to 50 per cent longer than American designs. Length in itself could be a responsible factor in the troubles encountered, resulting in longer shafts and bearing spacing, and more expansion. Foundation design would also be simplified, plant building volume reduced, and critical materials saved by more compact designs. The use of slip-jaw clutches between turbine and generator was noted, an arrangement which has proved undesirable on American units, and of which the use was discontinued some years ago. Such clutches, particularly as units get larger, do not slip, and burned-out thrust bearings result.

Many troubles with the units occurred in the first year of operation. Seventy per cent availability on units during the first year is not uncommon. In fourteen of the sixteen steam plants visited new units were down for repairs. Shaft kinks and bearing misalignment were the main causes of trouble, but some blade trouble developed during this period.

The availability of American machines during the first year has been much higher than that indicated in Britain. A closer tie between British and American turbine manufacturers, whereby problems could be discussed, might help in improving dependability. Further, such an arrangement might result in the adoption of larger-sized turbine units.

Hydrogen cooling of generators is not used in Britain to any great extent, but this is understandable in view of the size of the present units. On larger units now on order hydrogen cooling will be more generally used. This is considered not only successful but essential in American practice, because of the reduction in generator size or, conversely, the much higher capacity generators which it permits. Several grounded fields were reported, and in most instances they were sent back to the manufacturers for rewinding. The expansion and elongation of the copper coils apparently caused the trouble. One generator had lost a top generator coil which had been removed and sent to the manufacturer for repair. No regular schedule of dielectric testing of generators is being followed. Several large companies in America are making these dielectric tests on generators and have found weak coils, and were able to repair them. If these coils had grounded during operations, a complete restacking of the laminations and rewinding job would have been necessary.

A study of quick or controlled starting should be made, as the practice in Britain now varies from half an hour to five hours in the different plants visited. With the advent of larger units, the present older machines will have to be shut down at night and started again each week-day morning. The quick-starting technique that is now being used in America by several of the large utilities should be taught to the British operators.

(To be continued)

An Ultrasonic Equipment for Descaling Boilers

In the "Crustex" boiler descaler described here, ultrasonic vibrations are generated and transmitted through the boiler water to remove scale. The descaling action depends upon the difference in the moduli of elasticity of the scale and of the steel underneath and is effective in all parts of the boiler reached by the pulses of ultrasonic energy.

ULTRASONIC energy is used in the "Crustex" boiler descaler to disrupt the scale deposited in boilers by hard water and to prevent the scale from building up. The principle of operation is to generate ultrasonic pulses of energy and to transmit them through the boiler water to those parts of the boiler where scale tends to form. Because the scale and the metal upon which it is deposited have different moduli of elasticity the effect of the ultrasonic pulses of energy is to cause the scale to fracture and flake off, the fragments being ejected by the usual blowdown.

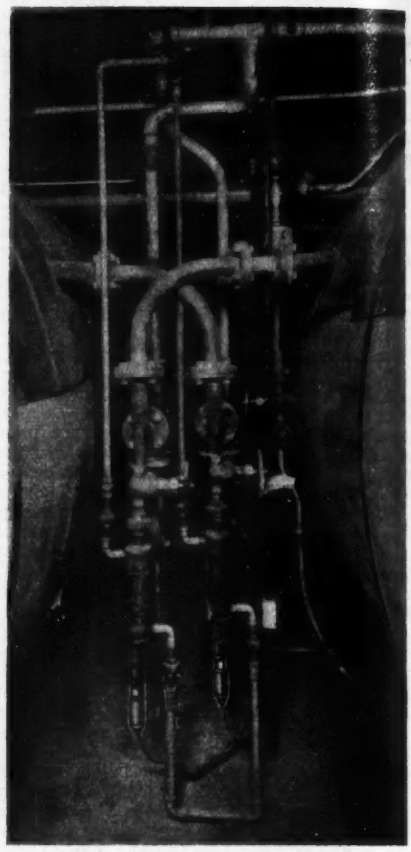
The " Crustex " apparatus was first developed and made in Switzerland and the British version of the product, illustrated here, is made by H.N. Electrical Supplies, Ltd., Rochelle Works, Brixton Hill Place, London, S.W.2.

The equipment consists of two parts, a generator and an oscillator for producing pulses of energy at 28,000 c/s and directing them through the boiler water. The generator is a simple transformer and valve rectifying circuit which is housed in a dustproof sheet metal case, 13in by 10in by 6in, and supplies pulses of direct current to an oscillatory circuit consisting of a condenser and a solenoid. The oscillator is fitted to the boiler as shown in one of our photographs ; it takes the form of a nickel-plated brass cylinder, 1½in diameter and 5in long, which contains a nickel tube surrounded by the solenoid of the oscillatory circuit. The generator is wall mounted at any convenient place up to 50 yards from the boiler and is connected to the oscillator by flexible cable.

Our simplified sketch of the oscillator shows the principle of operation. The condenser *A* is charged from the rectifier circuit of the generator and is discharged through the solenoid *B*. Alternate charging and discharging of the condenser is effected by the mercury commutator *C*. The pulses of current in the solenoid *B* produce magnetostriction (contraction and expansion under the influence of a magnetic field) in the nickel tube *D*. Damped pulses of vibration are thereby produced in the nickel tube, the frequency being 28,000 c/s. At the mid point of the nickel tube a node is formed in the vibrating system by brazing the tube to the oscillator body *E* which is attached by the threaded portion *F* to some convenient point of the boiler. The damped oscillations are then transmitted from the free end of the nickel tube, which is closed by a metal disc, into the water.

The oscillator is attached to the boiler at a convenient place to give the ultrasonic pulses free access to those parts of the boiler where scale tends to form. A typical installation is depicted in the photograph reproduced here. It shows an oscillator fitted to each of two hand-fired Danks " Super Economic " boilers having a rated output of 3000 lb per hour at 100 lb per square inch. In both boilers the oscillator is connected into the feed water connections and is provided with a water jacket so that, if the feed water temperature should rise, the effectiveness of the oscillator may be maintained. A precaution, illustrated in this installation, is that, to avoid undue attenuation of the ultrasonic pulses, the radius of the feed water pipe bend should not exceed 8in. Installations such as this are typically suitable for fire-tube boilers. In evaporators fed with high-pressure steam the " Crustex " oscillators can be fitted in the boiler end plates. In sea water evaporators a suitable position would be near the sea water inlet.

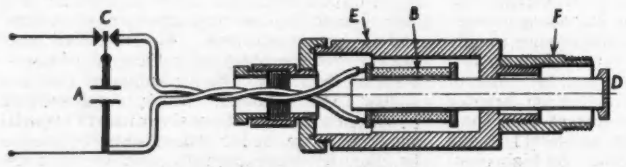
Generally the system is applicable to plant operating with pressures up to 450 lb per square inch and, for water of average hardness, with evaporative rates up to 15,000 gallons per hour. Under such conditions scale is removed continuously as it is formed, the general appearance of the flaked deposits being as shown in one of the illustrations on the opposite page.



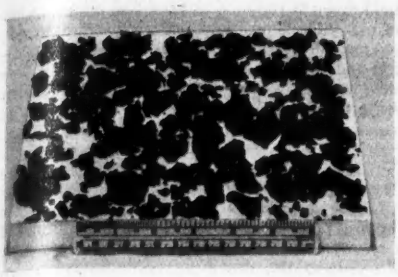
Oscillators Installed on Two Boilers

A deposit of eggshell thickness is left on the tubes and plates : as the deposit builds up beyond that thickness so it flakes off. When the " Crustex " equipment is fitted to an existing installation, in which the existing scale may be thicker, the dislodgment of scale takes a different form, and the lower photograph shows the typical appearance of scale removed in such an instance after a few weeks of operation. Some of these deposits are up to 1in thick, with the appearance of encrustations formed over a period of years in inaccessible parts of the boiler.

The generator operates from a mains electricity supply of 200/250V at 50 c/s, has a consumption of 20W and is capable of supplying

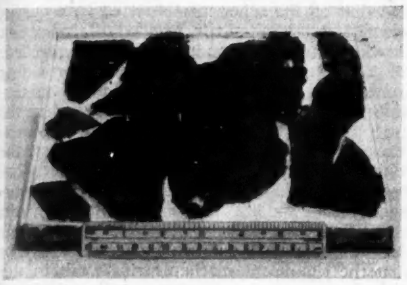


Simplified Diagram of Oscillator



Scale Dislodged During Normal Operation

four oscillators. The only moving part in the apparatus is the mercury commutator which initiates and maintains the oscillations. This switch, shown diagrammatically at *C* in our simplified illustration of the oscillator, consists essentially of a quartz U-shaped tube containing mercury. The upper portion of each arm of the U tube is a bulbous chamber containing hydrogen and each contains an electrode, the bottom of which is just above the mercury in the static position. One of the chambers also carries a



Scale Dislodged After a Few Weeks' Operation

tungsten filament which dips into the mercury on its side of the U tube. On switching on, the tungsten filament is heated and causes the hydrogen to expand, which depresses the mercury on that side of the U tube and raises it on the other. In this way the column of mercury is set in oscillation and the amplitude of the oscillations is built up until the mercury makes and breaks contact alternately with the electrode in each limb of the U tube. The making and breaking of the contacts is maintained by the oscillation of the mercury column as long as the apparatus is switched on.

Short Notice

Petroleum Measurement Tables. Prepared by the American Society for Testing Materials, and the Institute of Petroleum. London: The Institute of Petroleum, 26, Portland Place, W.1. Price 50s.—This volume is part of the complete collection of A.S.T.M.-I.P. Petroleum Measurement Tables and employs British (Imperial) units of measurement, the companion editions covering the United States and Metric Systems of measurement. The tables, which are based on the latest scientific data, provide a means of computing oil quantities in British units of weights and measures, while the number of significant figures given ensures that accuracy is not lost in any subsequent arithmetical calculation. There are full and accurate tables for specific gravity and volume reduction to 60 deg. Fah. and for weights per unit volume and volumes per unit weight over the specific gravity range 0·500 to 1·100. Each table is preceded by explanatory notes, including a statement of the gravity at which the table must be entered, and a worked example of its use. In addition to the principal tables are those setting out the conversion factors for measurement, temperature conversions, the relationship between A.P.I. gravity and specific gravity, the relationship between long tons, gallons and tons per barrel, and many other tables which transpose one unit to another and convert to metric measurement.

Fuel-Oil Ash Deposition in Open-Cycle Gas Turbines

By A. T. BOWDEN, Ph.D., B.Sc. (Eng.), M.I.Mech.E.,* P. DRAPER, M.I.Mech.E.,† and H. ROWLING, B.Sc. (Eng.) G.I Mech.E.‡

In this paper read before the Institution of Mechanical Engineers in London last Friday, April 24th, the authors begin by discussing the nature and occurrence of the ash forming constituents in the fuel oil and find that the methods of removing these constituents would destroy the price differential between residual and distillate grades. The authors then examine two promising methods of reducing ash deposition, one technique being concerned with a controlled form of combustion, the other involving the use of additives. In the abstracts chosen below the sections dealing with the removal of ash forming constituents and the mechanism of deposition have been omitted.

The Ash from Residual Fuel

The term "residual fuel" is applied to any fuel which contains the residue from a refinery distillation or cracking of crude petroleum. During this processing the ash-forming constituents become concentrated in the residue. Residues from different processes may be blended with each other, or with a distillate, to produce the required viscosity, which may range from less than 50 to above 6000 seconds (Redwood 1 at 100 deg. Fah.). The ash of such fuels may be less than 0·01 per cent and up to about 0·1 per cent.

Little attention has been paid in the past to the composition of fuel-oil ashes, only the total ash normally being determined. This is understandable because the ash is exceedingly small and for most purposes could be considered insignificant. Investigations such as were carried out prior to 1945 on these trace elements in petroleum from which the ash is derived were almost entirely of academic interest but, with the development of the industrial gas-turbine and the interest in the possibilities of running on residual fuel, much more attention is now being paid to ash composition. Additionally, geological information can be obtained from the trace elements which may assist oil exploration and, with these new interests, it may be expected that knowledge of the occurrence of the ash-forming constituents will increase rapidly during the next few years.

The variation in ash composition is enormous, not only between crude petroleums from fields in different parts of the world, but also very often between those from wells in the same oil field, and no generalisations linking ash composition with source of the "crude" can be made. In addition, the residual fuels obtained from the crudes are frequently blended in the refinery from considerations of properties unconnected with the ash composition.

The presence of a very large number of elements has been detected in crude petroleum, including some that are radioactive; the majority of these are in very small quantities and have been observed only by spectrographic means. However, if those elements which usually appear in concentrations of less than 10 parts per million (p.p.m.) of the fuel are neglected, the number is very much reduced, and the main ash-forming constituents commonly found in addition to sulphur are aluminium, calcium, iron, magnesium, nickel, silicon, sodium, vanadium, and, in some instances, zinc.

It may not be safe to neglect from consideration elements appearing in amounts of less than 10 p.p.m. of the fuel for these may exert an influence on ash deposition even at this low level of concentration, for example, by forming on their own or with other compounds products which are molten or sticky at the temperatures in the gas turbine. Even in small proportions such compounds could produce heavy deposition by trapping other dry ash particles by a "fly-paper" action. Certainly a number of anomalous results have been obtained in the authors' deposition tests which have so far been unexplained, and these could conceivably be due to such action by unidentified trace elements.

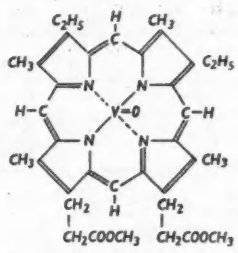
* Chief Research Engineer, C. A. Parsons and Co., Ltd.
† Head of Gas-Turbine Section, Product Development and Research Department, Shell Petroleum Company.
‡ Engineer in the Gas-Turbine Section of the Product Development and Research Department, Shell Petroleum Company.

However, interest to date has been confined to the major elements of the ash.

The States of Trace Elements in Petroleum

It can readily be understood that, owing to the complexity of the chemical composition of petroleum and the very small concentration of the metals and other trace elements, the determination of the chemical states and the physical forms in which they exist in the oil is extremely difficult. There has been little interest in the past in obtaining this knowledge, and although recently for geological and other reasons the subject has been receiving somewhat more attention, the total information available is not great. However, before the question of the removal of the ash-forming substances from the fuel can be considered, it is important to examine the forms in which they may be present and how they come to be in the oil.

It is now generally accepted that many of these trace elements are derived from the animal or vegetable remains from which the petroleum is formed, and one of the explanations of the wide differences found in the metal contents of crude petroleums is that this is affected by the origins of the oil. Examples of possible sources of some of the metals are animal bones yielding calcium, seaweed which contains nickel, certain crustaceans and molluscs rich in zinc, and a number of marine creatures such as sea squirts which have appreciable vanadium contents. The work of several investigators (Treibs, 1936; Woodle and Chandler, 1952) have shown strong evidence that a number of the metals are present as oil-soluble organo-metallic compounds, and it is probable that iron, nickel and vanadium exist in this form. It is thought that these compounds cover a wide range of molecular weight in the crude oil and the compounds of lower molecular weight may be distilled off with the hydrocarbons of low molecular weight, thus giving rise to the ash of the heavier distillate fuels. The amount of this ash is, of course, extremely small and even for gas turbines may be considered negligible. The bulk of the metal compounds, being of relatively high molecular weights, remain, and therefore become concentrated, in the residues. The presence in crude petroleum of an oil-soluble organo-metallic compound known as vanadium porphyrin has been observed by several workers and Skinner (1952) ascribes to this the formula :—



This is interesting because similar complexes are iron porphyrin (hæmatin), the red colouring matter of blood, and magnesium porphyrin (chlorophyll), the green colouring matter in plants, and this suggests that the origin of many of the trace metals is connected with the process of formation of petroleum.

In addition to the metals thus associated with the origins of petroleum, other elements may be introduced at later stages in its life. Thus the chlorides of sodium, magnesium, and calcium may be introduced by contact with water, especially sea-water, in the oil reservoir, and sand and clay (giving rise to silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3) in the ash) from the drill hole, even before the oil has undergone refinery treatment and transportation. These latter may cause pick-up of iron (ferric oxide (Fe_2O_3)) from pipes and tanks and further quantities of sodium, calcium, and magnesium by sea-water contamination. There is an essential difference in this group of ash-forming constituents in that they are all inorganic and insoluble in the oil. They may be present either in suspension in a micro-crystalline state or dissolved in water which is emulsified with the

oil. A further mechanism of introduction of metals is the action of naphthenic and other acids present in the crude petroleum, and the metal naphthenates thus produced are mostly oil-soluble. Table I gives a summary of the forms in which the more common ash-forming elements are thought to occur in crude petroleum.

In the distillation process the temperatures reached are not high and all the inorganic

TABLE I—*States of Trace Elements in Petroleum*

Aluminium	Inorganic	Insoluble	Complex alumino-silicates in suspension
Calcium ...	Organic	Soluble	
	Inorganic	Insoluble	Calcium salts in suspension or dissolved in emulsified water
Iron	Organic	Soluble	Possibly porphyrin complexes
	Inorganic	Insoluble	Iron oxides in micro-crystalline state in suspension
Magnesium...	Organic	Soluble	
	Inorganic	Insoluble	Magnesium salts dissolved in emulsified water or in suspension in micro-crystalline state
Nickel	Organic	Soluble	Probably porphyrin complexes
Silicon ...	Inorganic	Insoluble	Complex silicates and sand in suspension
Sodium ...	Inorganic	Insoluble	Largely sodium chloride dissolved in emulsified water or in suspension in micro-crystalline state
Vanadium ...	Organic	Soluble	Probably porphyrin complexes
Zinc	Organic	Soluble	

compounds are unaffected. Those inorganic compounds present in solution in water will, however, on distillation be left in the residue in suspension in a finely divided state owing to an evaporation of the water. The evidence is that the organic compounds are stable up to about 350 deg. Cent. and therefore are also unchanged by distillation.

The Chemistry of Fuel-Oil Ash

In the combustion chamber chemical changes of most of the metallic compounds take place both by the action of the temperature of the flame, which will normally be about 1600 deg. Cent., and also by reaction with sulphur trioxide

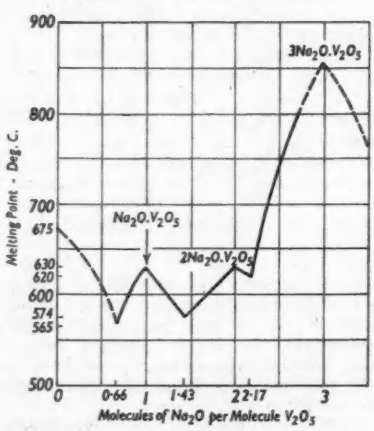
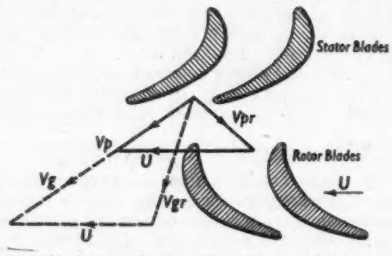


Fig. 1—Melting Point Diagram for System V_2O_5/Na_2O

and sulphur dioxide. The large organo-metallic molecules undergo thermal breakdown and the metals appear as inorganic compounds. The sulphur in the fuel (of which there may be 1 per cent or more) is oxidised on combustion to sulphur dioxide and sulphur trioxide and the quantity present in the gas stream is many times more than that required for the theoretical conversion of all the metal oxides to sulphites and sulphates. In practice this does not occur because some of the metals do not readily form these compounds in this way and also because the sulphites, and in some cases the sulphates, are not stable at the gas temperatures involved. Both sodium and calcium form sulphates readily and these metals often appear in this form in turbine deposits.

Of the three sodium sulphates, the bisulphate ($NaHSO_4$) and the pyrosulphate ($Na_2S_2O_7$) are unstable above 250 deg. Cent. and 460 deg. Cent., respectively, and may therefore be thought to be non-existent in gas-turbine practice where normal turbine-inlet temperatures are much higher. However, it may well be that local conditions are suitable for the formation of these salts and, once formed, there is probably insufficient time in most gas turbines for decomposition to take place. In one turbine deposit



Suffix *g* refers to gas velocity ; suffix *p* refers to particle velocity

Fig. 2—Mechanism of Ash Deposition on Convex Surface

examined by the authors there was evidence that the pyrosulphate was present.

In addition to the simple oxides and sulphates of the various metals, compounds may also be formed by reaction between them. For instance, there is a series of sodium salts formed from various vanadium acids, and the melting points of some of these is shown in Fig. 1 (reproduced from Canneri, 1928), which also shows the low melting point of the eutectic mixtures of sodium oxide (Na_2O) and vanadium pentoxide (V_2O_5). Other complex sodium salts contain both tetravalent and pentavalent vanadium (vanadyl vanadates) and the presence of one of these—$Na_2O.V_2O_4.5V_2O_5$—in gas-turbine deposits is common in the authors' experience. Other compounds also identified in gas-turbine deposits are iron and nickel complexes of the spinel type. It is clear, therefore, that the number of compounds formed may be very great and in the authors' view no simple explanation, such as has been frequently put forward, that deposition is due to the presence of one or another particular element, is correct.

The most significant characteristic of a compound from the standpoint of deposition is probably its melting point, and of the compounds which might be expected to be present, or which have actually been identified in turbine deposits, there are no stable compounds having melting points below 625 deg. Cent. It is thought, therefore, that if the formation of deposits is due to the presence of a material which is molten or sticky, then this sticking agent is either one of the sodium sulphates mentioned above or is a mixture of low melting point of some higher melting point compounds.

Ash Removal from the Gas Stream

Removal of the ash particles between combustion chamber and turbine has been considered but the problems involved are very great. Three methods are possible :—

(1) Centrifuging, for example, by cyclone separators.

(2) Electrostatic precipitation.

(3) Filtration by screens of refractory material.

As far as can be seen, it is not feasible to remove either the ash-forming material from the fuel, or the ash itself from the gas stream, and the conclusion is therefore that efforts must be concentrated on means of passing the ash through the turbine with the minimum of undesirable effects. At the outset the turbine designer can help by keeping the gas "turn-round" to a minimum and the blade pitch to a maximum ; indeed, it may be worth while to accept a slightly lower efficiency in return for less sensitivity to ash deposition.

The Effect of Individual Ash Components

The first heavy-fuel-oil tests on the Parsons experimental gas turbine (Bowden and Jefferson, 1949) were carried out on an ordinary boiler fuel known at the time as pool fuel oil, and when serious ash deposition occurred an approach was made to the oil companies to seek an explanation and cure. It was found on analysis that the fuel was quite normal, the leading features being :—

Viscosity (Redwood 1 at 100 deg. Fah.)	170 seconds
Sulphur content	1·52 per cent
Ash content	0·044 per cent
Sodium expressed as Na_2O	16·3 p.p.m. of fuel
Vanadium expressed as V_2O_5	295 p.p.m. of fuel

Little was known of the mechanism or the chemistry of the process of ash deposition and there was a widely held belief that the trouble was due to the vanadium compounds present. There was no evidence to support this idea and it was decided to run a test with a fuel containing almost no vanadium.

After much searching a fuel oil was found of which the vanadium content was only 4·6 p.p.m., the bulk of the ash being sodium (1440 p.p.m. as Na_2O) and the result was a rate of deposit build-up far greater than had been obtained with any previous fuel. To investigate further the effect of different ash components a series of tests was run using gas oil as the fuel, into which was dissolved in each case a different organo-metallic compound. The results of these tests are shown in Fig. 3, in which the turbine resistance is taken as 1/(effective area)^2. It is seen that the high deposition rate of sodium is confirmed and that all the other metals tested gave curves which, after an initial rise, levelled off, indicating that an equilibrium condition had been reached. Of course, these particular tests, while providing some useful information, are of limited applicability, since in residual fuels many elements are present and complex compounds and mixtures are formed in the ash. Nevertheless, the high deposition rate of sodium compounds has been confirmed for residual fuels, that is, the higher the sodium content the greater the deposition rate. The explanation of the high deposition rates of sodium compounds may be that the significant mechanism at work in this instance is particle diffusion, small particles of sodium sulphate being formed in the gas stream by condensation, after vaporisation in the flame zone. However, the appearance of the deposits suggested a bonding action and it is not easy to explain this unless it is assumed that sulphates

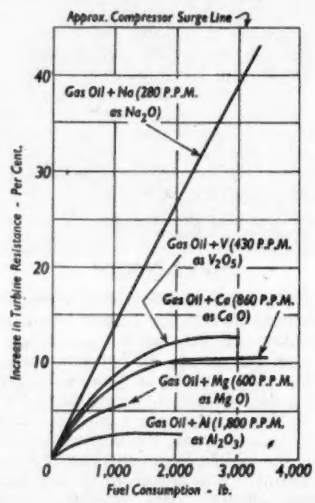


Fig. 3—Effect of Individual Ash Components

are present other than sodium sulphate (Na_2SO_4), which has the relatively high melting point of 880 deg. Cent. Mixtures of Na_2SO_4 and other sulphates might have a low enough melting point, or a small amount of sodium pyrosulphate with its melting point of 400 deg. Cent. could act as a sticking agent if present.

Reduction of Ash Deposition by Combustion Control

At the same time as these investigations were being carried out on the turbine, a rig was set up to examine the problem. Gas from a combustion chamber, a refractory-lined type of 15in internal diameter, was passed over a row of static blades representing the first-stage stator

blades. The conditions of gas velocity, gas temperature, blade pitch and blade profile were kept the same as on the turbine (in fact, actual turbine blades were used). These were thought to be the significant features. However, in certain other respects the rig differed considerably from the turbine. First, it operated at substantially atmospheric pressure and, secondly, for convenience, a combustion system designed for another gas turbine was used and this had both a much higher combustion intensity rating and a different type of burner. It is now known that all these differences have an important effect on deposition. The design combustion intensity of the rig flame-tube was $1 \cdot 1 \times 10^6$ B.Th.U. per cubic foot-hour atmosphere and this should be compared with a corresponding intensity of the combustion chamber of the experimental gas-turbine of $0 \cdot 2 \times 10^6$ B.Th.U. per cubic foot-hour atmosphere. Pressure-jet atomisers were used in the rig at a fuel-supply pressure of about 200 lb per square inch, whereas in the turbine the atomiser used was either of the pressure-jet type, operating at fuel pressures of 400–600 lb per square inch, or an air-blast type.

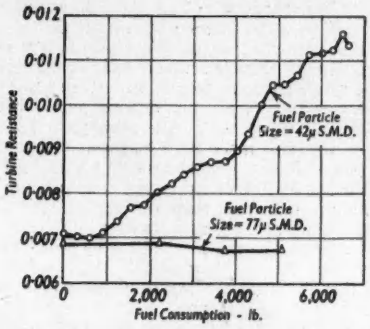
It was not expected that the rate of deposition would be as high on the rig as it was in the turbine because the amount of ash passing each blade per unit time was about one-quarter of the amount passing a corresponding turbine blade.

When operating this rig on a boiler fuel of viscosity 6000 seconds (Redwood 1 at 100 deg. Fah.) it was found that even when allowance was made for the lower ash concentration by running for a correspondingly longer time, the amount of deposit was negligible compared with that obtained in the turbine. Investigation of this led to the discovery in the combustion chamber exhaust gas of a quantity of small carbon particles although the exhaust was visibly quite clear. These particles were hard, dry, roughly spherical solids of sizes from 1 to 50 microns diameter and consisting largely of carbon (about 97 per cent), the remainder being ash. Even with this high percentage of carbon the combustion loss represented by these particles was only 1·1 per cent of the heat input. This discovery immediately suggested an explanation for the lack of deposition. First, it was evident that something like 50 per cent of the ash was associated in some way with these particles and therefore might be prevented from sticking to the blades and, secondly, it seemed very likely that the particles themselves would have a strong scouring effect. This latter effect would influence mostly the leading edges and concave surfaces of first-stage stator blades but the effect on the following blades would be governed by the mechanism illustrated in Fig. 2. Probably both of the mechanisms play their part but it is certain that the scouring action alone is not sufficient to suppress deposition. It is possible to obtain complete combustion of the carbon, thus liberating all the ash into the gas stream.

It has been suggested that ash associated with the carbon particles gets there by condensation from the vapour phase, the particles acting as nuclei. It is obviously very difficult to determine from examination of the particles whether this is so or not, but the results of the tests on a high-sodium fuel mentioned below indicate that any condensation on to the particles involves an insignificant quantity of ash only and therefore has a negligible effect on deposition.

It is important to distinguish between these carbon particles and the much smaller ones which give rise to visible smokes. The latter are caused by chilling of the vaporised fuel constituents and are of the size order 0·05 micron diameter. Such particles play no part in this particular method of reducing ash deposition, they are too small to cause scouring, and they contain no ash.

There are various ways of controlling the completeness of combustion of the fuel droplets, and in a conventional combustion system these are combustion temperature, particle size, and residence time. Of these, in a developed combustion system, particle size is the most easily controlled factor. On the experimental engine this was done by the use of two different types of burner, one an air-blast type and the other a spill-controlled pressure-jet atomiser. Under the conditions of operation of these the surface mean diameter of the fuel sprays produced were 42 microns for the air blast and 77 microns for the pressure jet. When the air-blast atomiser was used, deposition was rapid (Fig. 4) and no carbon was evident in the gas stream. With the



Details of fuel: viscosity (Redwood 1 at 100 deg. Fah.), 2370 seconds; specific gravity at 60/60 deg. Fah., 0·9625; ash content, 0·067 per cent.

Ash analysis	Percentage ash	P.p.m. of fuel
Vanadium as V_2O_5	72·9	490·0
Sodium as Na_2O	11·6	78·0
Calcium as CaO	1·4	9·4
Nickel as NiO	7·0	47·0
Iron as Fe_2O_3	2·4	16·0
Sulphate as SO_3	4·7	—

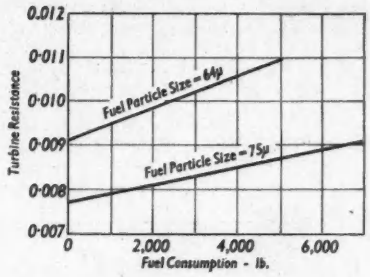
Fig. 4—Effect of Fuel Particle Size on Deposition

pressure-jet atomiser no increase in turbine resistance occurred over the period of the test and carbon particles (not "smoke") were present in the gas stream to the extent of 0·5 per cent expressed as a combustion loss. That the effect was due to particle size was confirmed by the result obtained when a simplex atomiser was used operating at a supply pressure of 1000 lb per square inch, which was designed to give the same quality of atomisation as the air-blast burner. Again deposition was very rapid.

It is not suggested that from these results complete immunity from deposition by the use of combustion control can be claimed but it is obvious that an improvement of the first order has been achieved. The spread of particle size in sprays from gas-turbine atomisers is fairly large, and even under conditions where most of the droplets are burnt down to a carbon sphere there are always the smaller droplets which are completely combusted leaving only the ash. To obtain the best results from this method of deposition control, a fuel spray of droplets of uniform but controllable size is required. Both fuel pressure operated and air-blast atomisers give sprays of high dispersion. The only practical atomiser which would give a uniform spray is the spinning disc type, but it has so far not been found possible to maintain this effect above a fuel flow of about 25 lb per hour.

In Fig. 5 is shown the result obtained on the gas turbine using a fuel of high sodium content and with a fuel particle size of 75 microns, and this should be compared with the curve in Fig. 4 for the test at a similar particle size but using the high vanadium fuel. It is seen that deposition was more rapid with the high sodium ash, but in considering this result it must be borne in mind, first, that such a high sodium content is unusual, and secondly, that to obtain such a concentration the bulk of the sodium was added to the fuel in the form of an oil-soluble compound. It is possible that such an "artificial" ash would behave differently from a "natural" sodium ash.

It appears that sodium compounds volatilise from the fuel particle in the flame more readily than do, for example, the vanadium compounds.



Details of fuel: viscosity (Redwood 1 at 100 deg. Fah.), 1560 seconds; specific gravity at 60/60 deg. Fah., 0·952; sulphur content, 3·64 per cent; ash content, 0·09 per cent.

Ash composition	P.p.m. of fuel
Vanadium as V_2O_5	81
Sodium as Na_2O	180
Nickel as NiO	18
Iron as Fe_2O_3	27

Fig. 5—Effect of Fuel Particle Size on Deposition with High Sodium Fuel

The available vapour pressure data (Fig. 6) confirm that this is so if the sodium is present as chloride, and sodium oxide, which may exist at the temperature of the flame, sublimes at 1275 deg. Cent. (1 atm. pressure). Another suggested explanation is that the complex molecules of the vanadium compounds take longer than the simpler sodium compounds to undergo pyrolysis. The effect of the mechanism (whatever it may be) is indicated in Table II, in which are compared the vanadium/sodium ratios in the ash of three samples of exhaust solids with the corresponding ratio in the fuels used. These results indicate considerable loss of sodium by volatilisation. However, such high sodium fuel as used in the test is very abnormal and not likely to be met in practice, and even with such a fuel a considerable reduction in deposition rate was obtained by combustion control for, as mentioned earlier, it has been found that such high sodium fuels always give extremely high deposition rates, under normal conditions. It seems likely from this evidence that with high-sodium fuel the benefit to be obtained by combustion control may not be so great as it is, for example, with high-vanadium fuels.

TABLE II—*Vanadium/Sodium Ratios in Ash of Exhaust Solids*

	Rig		Experimental gas-turbine			
	In fuel	In ash of exhaust solids	In fuel	In ash of exhaust solids	In fuel	In ash of exhaust solids
V_2O_5	610 p.p.m.	63 per cent	505 p.p.m.	36·6 per cent	390 p.p.m.	34 per cent
Na_2O	550 p.p.m.	5·2 per cent	124 p.p.m.	1 per cent	150 p.p.m.	6 per cent
V_2O_5/Na_2O	1·1/1	12/1	4·1/1	36·6/1	2·6/1	5·7/1

A possible limitation to the use of this method of reducing deposition is that the particles may, over a period of time, cause erosion of the blades. This has not been evident on the experimental turbine but the total period of running under these conditions is not great. In an illustration in the original paper the erosion of the root of a gas-turbine stator blade was shown. Here the carbon particles were very large (mean diameter about 100 microns) and the period of operation was about 4000 hours. The localised effect at the blade root was due to the centrifuging action of the inlet scroll. It is considered that the degree of erosion is abnormal and was caused by the excessive particle size.

Reduction of Deposition by the Use of Additives

The use of a fuel additive in leaded gasolene to prevent the formation of lead deposits is well known and suggests that a similar means might be used to reduce turbine-blade ash

deposits. The deposits from leaded gasolene are due to a single element and the effectiveness of the additive is due in the first place to a chemical reaction. In gas turbines an additive which functioned by virtue of some physical effect might also be employed. The effect of an additive can be either to make the ash volatile in its passage through the turbine, to raise the melting point of ash components above the turbine inlet temperature, or to act as an abrasive. To these must be added the use of an additive to provide nuclei for ash condensation, because there is a possibility of such an effect, and also

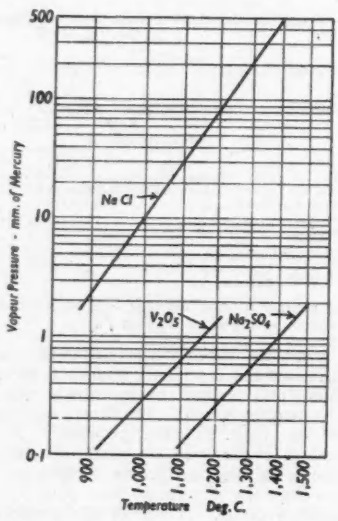


Fig. 6—Vapour Pressures of NaCl, Na_2SO_4 and V_2O_5

the use of an additive to render the turbine deposit water-soluble for ease of removal.

The vanadium in the ash might be converted to a volatile form by reaction with halogens, but at least one attempt to form vanadium chloride by the addition of carbon tetrachloride does not seem to have been successful (*Oil Engine and Gas Turbine*, 1950). Even if this were so it is still necessary to deal with the sodium. Little work seems to have been done on reducing ash deposition by means of an additive, but work has been done (McFarlane, Holdernesse and Whitcher, and Graham, Lewis and Taylor) on the use of additives against corrosion, and in the latter use the effectiveness of some compounds may be due to their causing less deposition. A series of tests was run on the experimental gas-turbine with combustion conditions set to give maximum deposition, using a residual fuel oil and a number of different additives. These were silicon, phosphorus, magnesium, calcium, aluminium and zinc. The results and details of the fuel are shown in Fig. 7. All the elements were added in an oil-soluble form. The use of silicon was suggested by Sulzer (1952), who had found a reduction in deposition with this element in rig tests.

It is seen that silicon proved to be the most effective of the elements tested, in fact there was no discernible increase in turbine resistance although there was some deposit on the blades at the end of the test. A considerable improvement was also made with magnesium and zinc. It is considered that the small particle-size of the products formed in the gas stream (less than 1 micron diameter) rules out the possibility of there being any abrasive action, but there is a possible clue to the mechanism by which these additives work. The work of the B.C.U.R.A. (Littlejohn, 1952; Whittingham, 1948) has shown that zinc, magnesium and silicon oxides are all effective in lowering the sulphuric acid dew-point of flue gases. Whether these oxides inhibit the formation of SO_3 or whether they adsorb the SO_3, or react with it chemically, after it has been formed, is not entirely clear, but the suggestion is that where fuel-oil ash is present the formation of low-melting-point sulphate (sodium bisulphate ($NaHSO_4$) and sodium pyrosulphate ($Na_2S_2O_7$)) is prevented. Table III gives a comparison of the ash analyses of deposit from the first-row stator blades with and without ethyl silicate added to the fuel. The ratios for V_2O_5, NiO, Na_2O and SO_3 for the two tests are very nearly the same, showing that the effect of the silica is one of dilution only. The iron is partly derived from sources other than the fuel and would therefore not be expected to keep a constant ratio. X-ray examination of the two deposits showed them both to contain the sodium vanadyl vanadate ($Na_2O.V_2O_4.5V_2O_5$) together with small quantities of $2NiO.V_2O_5$ and Na_2SO_4.

TABLE III—*Effect of Silica on Blade Deposits*

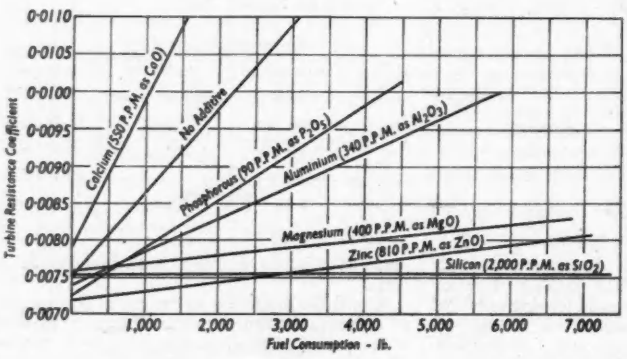
Deposit analysis	Fuel ICT/S/76, per cent, weight	Fuel ICT/S/76 plus 0·5 per cent $Si(C_2H_5)_4$, per cent, weight	Ratio
Vanadium as V_2O_5 ...	52·0	17·3	3·0
Nickel as NiO	4·3	1·6	2·7
Iron as Fe_2O_3	1·6	1·9	0·8
Sodium as Na_2O ...	18·0	6·0	3·0
Sulphate as SO_3 ...	25·3	9·2	2·8
Silicon as SiO_2	—	60·0	—

In addition, the deposit from the test in which ethyl silicate was added to the fuel contained amorphous silica.

This work tends to conform with the previous evidence given above which suggests that at the temperature conditions used in the tests (565 deg. Cent.) certain sodium sulphates give rise to the most severe forms of ash deposits. There are other possible explanations for the effectiveness of silicon, magnesium and zinc and there is insufficient evidence yet for any theory to be put forward with certainty.

To add any of the additives (say, silicon, magnesium or zinc) in an oil-soluble form is ruled out on the score of the cost of these compounds and therefore cheap inorganic compounds will have to be used. It is still to be seen whether the additive will be as effective when added as an inorganic compound, either direct into the air stream or in suspension in the oil. When, in suspension in the oil it must be added only shortly prior to combustion, that is, into the turbine fuel-system. In any case, to blend in an additive to a residual fuel at oil company installations would considerably increase the price to the user owing to difficulties of segregating fuels for gas-turbine use from those for use in boilers, &c.

The authors consider it likely that neither of the above methods may be completely satisfactory on its own, but that a combination of factors such as turbine design, combustion control, and the use of additives, will eventually enable gas turbines to operate successfully for reasonably long periods on residual fuel without intolerable loss of performance.



Details of fuel: viscosity (Redwood 1 at 100 deg. Fah.), 890 seconds; specific gravity at 60/60 deg. Fah., 0·948; ash content, 0·084 per cent.

Ash composition	P.p.m. of fuel
Vanadium as V_2O_5	390
Nickel as NiO	43
Sodium as Na_2O	155
Iron as Fe_2O_3	14
Calcium as Cao	10
Aluminium as Al_2O_3 }	14
Lead as PbO }	

Fig. 7—Effect of Various Additives on Deposition

British Standards Institution

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DOMED ENDS FOR TANKS AND PRESSURE VESSELS

No. 1966 : 1953. Price 2s. 6d. This standard has been prepared to meet a need to rationalise the large numbers of shapes and sizes of ends now being used; an attempt has been made to standardise the sizes and shapes of ends most commonly used. It is fully appreciated, however, that there are numerous manufacturing dies in existence which will produce ends varying slightly in certain dimensions from those given in this standard and that these ends will continue to be used for some time to come, but it is strongly recommended that when new dies are produced they conform to the proportions specified in this standard. The standard has been based largely on mild steel ends, but many of the forms and proportions specified apply to ends made from other materials.

It specifies the boundary dimensions of three types of dished and flanged, pressed or spun ends commonly used as end closures of pressure vessels, tanks and similar equipment, i.e. :—

(*a*) Deep dished and flanged ends, 2 : 1 ratio. (i) Of semi-ellipsoidal shape with a profile following (within the stated tolerances) the shape of a semi-ellipse with a ratio of major axis/minor axis of 2 : 1. (ii) Of arc dished shape with a depth of dishing measured from a plane passing through the point where the straight flange joins the knuckle radius, equal to 0·25 times the inside diameter of the end. A range of ends from 12in to 120in nominal diameters is given.

(*b*) Dished and flanged ends having a depth of dishing measured from a plane passing through the point where the straight flange joins the knuckle radius nominally 0·169 times the inside diameter of the end. The nominal diameter may be either the outside diameter or the inside diameter. A range of ends from 12in to 120in nominal diameters is given.

(*c*) Shallow dished and flanged ends (tank style), having ends dished to a large radius and provided with a knuckle radius of 1½in. The nominal diameter is the outside diameter of the straight flange. A range of ends from 36in to 108in nominal diameters is given.

Tolerances are given for circularity, thickness and profile, together with tables of dimensions in respect of inside or outside diameters, depth of dishing, dishing radius, knuckle radius and lengths of straight flange.

PRESSURE-OPERATED RELAY VALVES FOR USE WITH TOWN GAS

No. 1963 : 1953. Price 2s. 6d. This standard specifies minimum requirements in the performance of relay valves, standardises methods of testing, and facilitates maintenance and the replacement of accessories by the use of British Standard pipes, fittings and threads.

It is pointed out that the variety in the design and methods of production of both valves and connections makes any attempt at complete dimensional standardisation undesirable. The standard does, however, specify requirements for connecting unions to either British Standard steel or light gauge copper pipes. The type of union and pipe is left to the option of the purchaser, although the use of steel for weep pipes is not recommended where there is danger of corrosion.

The standard covers pressure-operated relay valves of nominal sizes ¼in to 6in, for use in low-pressure gas systems up to 12in w.g. It specifies materials and constructional requirements, shut-down times and minimum gas rates, and also specifies minimum requirements for tests for internal and external soundness. Three alternative suitable methods of test are given and illustrated diagrammatically in an appendix. The standard includes a diagram of a typical relay valve.

Geared Steam Shunting Locomotives

An industrial steam shunting locomotive being made by Sentinel (Shrewsbury), Ltd., is built up of standard units. Engines to this design can be fitted with gearing to suit individual shunting conditions and give maximum efficiency at specified speeds. It is stated that under normal conditions these locomotives can be prepared for service under a full head of steam within an hour.

WE recently took advantage of an opportunity to inspect a 200 b.h.p. steam shunting locomotive of the latest design built by Sentinel (Shrewsbury), Ltd., for work in industrial yards and sidings. Shunting locomotives have been built by the firm for many years in two sizes—one weighing 24 tons and developing 100 b.h.p. and the other weighing from 29 to 34 tons and developing 200 b.h.p. at the wheels, but unlike the general design of steam locomotives used for shunting purposes, these Sentinel locomotives are each built to work at a specified shunting speed and at that speed to develop maximum power.

These locomotives have a compact water-tube boiler supplying steam to a relatively high-speed, totally enclosed vertical engine. The drive is transmitted to the axles through a reduction gear unit, the overall ratio of which can be selected from a standard range to suit specified conditions. By using the correct gear ratio the engine is able to work at its most economical speed whilst the locomotive is performing the bulk of the services for which it is required. Use of the maximum adhesive weight of the locomotive is obtained by transmitting the drive through chains to both axles, and the fitting of the appropriate reduction gear to work with the high-speed steam engine gives a particularly even torque at the driving wheels. By selecting the appropriate high or low gear ratio the locomotive can be worked to its best efficiency when handling full or empty trains of trucks or working over gradients. Use of this reduction gearing also makes it possible to restrict engine and boiler sizes to a minimum for a given tractive effort and shunting capacity. With the design adopted, fuel consumption is kept low whilst a locomotive is at work and stand-by losses are proportionately reduced.

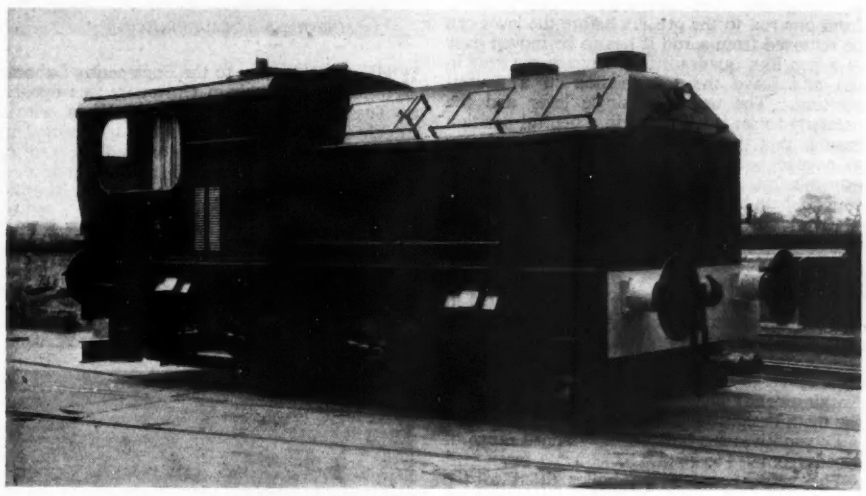
The drawing and photograph we reproduce on this page show one of the 200 b.h.p. locomotives and it should be pointed out that the general layout is similar in the case of the 100 b.h.p. locomotive, except that it is generally of lighter construction and has only one instead of two steam engines, and a smaller boiler. A majority of the mechanical parts of the two locomotives made are interchangeable so that a minimum number of spares need only be kept when operating both types in an establishment.

The locomotive has a frame of heavy steel plates connected by suitable cross bars and steel plate head stocks, and it is strongly braced and gusseted to form a rigid structure. Plain bushed axleboxes mounted on laminated springs carried in spring brackets are located in position by adjustable radius rods. Disc wheels, fitted with tyres, are carried on forged steel axles coupled together by heavy-duty duplex roller chains. A combined steam and hand brake gear operates blocks on all four wheels, and the sanding gear fitted is effective for operation in each direction of working. The axleboxes, spring gear and radius rods are all mounted outside the main frames and, together with the brake rods, are easily accessible for adjustment and maintenance purposes. A heavy beam set across the main frame at each end of the locomotive and in close proximity to the rails can be used for re-railing purposes. These beams also prevent the locomotive, in the event of derailment, falling between the tracks. Protection against damage to the gear cases is also thus provided.

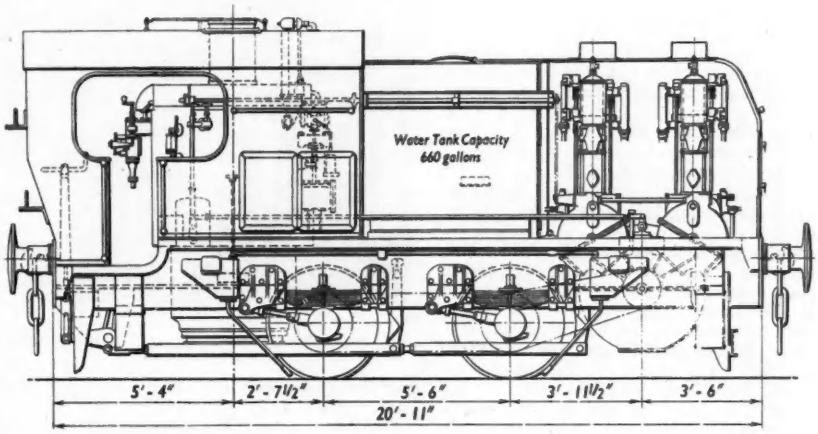
The boiler, bunker and controls are mounted on the frame behind the rear axle with the driver's footplate overhung behind them. The engines and reduction gear unit are mounted forward of the front axle and the water tank is carried between the engine and the boiler.

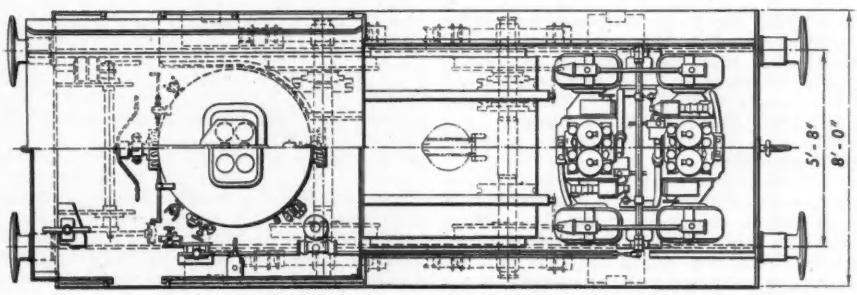
The engines are of a particularly straightforward totally enclosed design to give long, trouble-free working and easy accessibility for maintenance and inspection purposes. These engines are vertical high-speed, two-cylinder, double-acting units, developing 105 b.h.p. at about 450 r.p.m., with a boiler pressure of 275 lb per square inch and they can be run at up to 600 r.p.m. Each engine has 6¾in bore by 9in stroke cast iron cylinders in which cast iron pistons are carried on nitralloy steel piston rods reciprocating in substantial guides. The piston rods are coupled through cast iron cross-heads and forged connecting-rods to an alloy steel balanced crankshaft. Alloy steel poppet valves, which are operated by push rods from camshafts in the crankcase have cut-off's in each direction of 75 and 40 per cent. To adjust the valves for cut-off and for reversing purposes the camshaft is slid along in its bearings by means of a selector fork and control spindle. This fork is moved by suitable linkage mechanism, rod operated from the reversing lever in the driving cab. Each set of valves is mounted in a unit manifold on the cylinder, so that when the seats require regrinding at the end of a specified working period the complete assembly can be removed and replaced by a spare manifold in about an hour. With this arrangement of the valve manifold, users of the locomotive can maintain a spare unit and avoid necessity for taking a locomotive out of service, for more than an hour or so, whilst routine maintenance on the valves and seats is carried out.

The engine cross-head, crankshaft bearings, &c., are pressure lubricated by oil supplied from the sump by a small rotary pump. A



200 h.p. Geared Steam Shunting Locomotive





General Arrangement of 200 h.p. Geared Steam Shunting Locomotive

metered supply of oil from a separate mechanical lubricator is fed to the cylinders and valve gear.

The two engines are mounted on a massive cast steel reduction gearcase in which a heavy central countershaft is driven by pinions, slidable on splines at each end of the engine crankshafts. The two crankshafts have a pinion of different diameter on each end. Changing of the gear drive ratio is effected by sliding one pair of pinions out of mesh with a gearwheel keyed at one end of the countershaft and the other pair of crankshaft pinions into mesh with a similar gearwheel keyed at the other end of the shaft. The crankshaft pinions are moved along on their splines by means of racks which are operated by pinions keyed to rods extending from the driving cab. One rod on each side of the locomotive controls the two rack pinions on that side of the engines—the two high gear pinions being on one side and the two low gear pinions on the other. In the cab the control rods are situated one on each side of the boiler. Only one lever is supplied to operate the rods for gear changing purposes and when it is required to change gear it is necessary to move the lever from one rod to the other. Before the lever can be removed from a rod it has to be moved over to a gap in a quadrant to disengage the gear in use and leave the transmission in a neutral position. The use of a single lever and the necessity to set it with gear in a neutral position ensures that the driver cannot inadvertently try to engage both sets of gears and damage the transmission. Each of the driven gears on the countershaft has a sprocket wheel rigidly bolted to it and drive from these sprockets is transmitted by chains to the front axle. The front axle is coupled by driving chains to the rear axle of the locomotive.

The sliding two-speed gear can be supplied in three different ratios and this, together with the use of alternative sizes of secondary driving wheels on the countershaft, enables a standard locomotive to be easily adapted for particular working conditions without need for changes in the main design.

Locomotives are built for a standard range of speeds from 9·4 to 26 m.p.h.

The vertical water-tube boiler fitted to the locomotive is designed to evaporate 43,000 lb per hour, using average British steam coal of 13,500 B.Th.U. per lb. It has a working pressure of 275 lb per square inch. In cases where coal of an inferior nature is to be used, the boiler can be fitted with a special rocking firegrate. The boiler consists of an outer shell and an inner firebox in which four flats are pressed to form the tube plates for the cross tubes. The firebox has a heating surface of 51 square feet and the tubes a heating surface of 92·4 square feet, the grate area being 6·5 square feet. Superheater coils having an area of 41·2 square feet are arranged over the top of the tubes. Firing is effected through a large, conveniently placed, hinged door on the side of the boiler.

The feed water tank between the engines and the boiler has a capacity of 660 gallons and a steel plate bunker is designed to hold 12 cwt of fuel. The boiler is fed with water by means of a steam pump of adequate size controlled by a hand valve conveniently placed for operation by the driver. The object of this pump is to feed water to the boiler continuously at a rate to make good evaporation, and maintain a constant water level to avoid sudden cooling of the boiler by intermittent additions of large quantities of cold water.

The pump can feed at a maximum rate of 600 gallons per hour at twenty-five double strokes per minute. This represents 50 per cent more water than the maximum evaporative capacity of the boiler. The average rate of feed under heavy shunting conditions has been found to be eight double strokes of the pump per minute. A cold water injector is fitted for standby purposes.

A roomy driver's cab is fitted with large windows at the front and the rear and has the main controls conveniently placed for working from each side. These controls include a lever for gear changing—which is done with the locomotive stationary; a reversing lever; a double-ended hand lever for the throttle which incorporates a second lever for the release valve; a brake valve; and a screw hand brake.

The locomotives are designed throughout to give the maximum possible accessibility to all parts for inspection and maintenance. They are mainly of standard unit construction and when major overhaul is required in any locomotive unit such as the boiler, an engine, gearbox, &c., it can be removed and another unit substituted to keep the locomotive in service whilst work is carried out. The maker's state that under normal circumstances a locomotive can be prepared for service and under a full head of steam in less than an hour, and, as heavy firing is not required whilst running, a crew of only one man is necessary. When it is engaged in normal working to the specified design requirements it is claimed that the 12 cwt bunker of a locomotive bunker carries sufficient fuel for a full working day and the water tank of 660 gallons capacity will also suffice for periods of eight to ten hours' operation without refilling. The availability claimed is therefore greater than that normally associated with steam shunting locomotives.

Engineering Laboratories at Nottingham University

At Nottingham University, a scheme for increasing the accommodation available for the engineering department has recently been completed. A new block has been built, and with the extra space thus made available, the various laboratories and lecture rooms have been reorganised so that each year about ninety engineering students may be admitted.

THE new extension to the Engineering Laboratories at Nottingham University was opened on Tuesday of last week by Lord Hives, whose speech on that occasion was briefly reported in our last issue. This extension and the project of which it forms a part is notable in several respects, for it aims to contain an engineering department in the smallest space and yet to provide enhanced facilities. In the project, the Head of Department, Professor J. A. Pope, has adopted an approach to the training of engineers in which the order and scope of laboratory work has been extensively revised, enabling it to contribute more effectively to the assimilation of basic engineering fundamentals.

One of the governing factors in the conception of this project was the urgent need to relieve the congestion of the post-war years at Nottingham in the shortest possible period. It is of interest to note that in 1930 the number of full-time students in the department was seventeen; in 1940 it had risen to forty-four, had increased to 128 by 1946, and in 1950 there were approximately 200 students reading for degrees in engineering. These numbers obviously exceeded the available facilities and adequate training was obtained only by splitting each year into two main streams. Such congestion of course, was common to engineering departments elsewhere, and the congestion of the engineering students' syllabus itself, laboured under these conditions, must certainly have denied to them the favourable atmosphere and the more subtle benefits of a university training.

At Nottingham a particularly bold and necessarily experimental solution has been attempted. The building itself is utilitarian in construction and functional in design, and in terms of cost per square foot of floor area is particularly economical. The capital expenditure per student place, including equipment, has relatively been kept very low without sacrificing student amenities.

The University was faced with the decision of either drafting large schemes for the development of technology, or to put into operation a smaller scheme which would come into operation with the shortest possible delay, and in which a considerable amount of experimenting could be safely indulged without committing a great deal of capital.

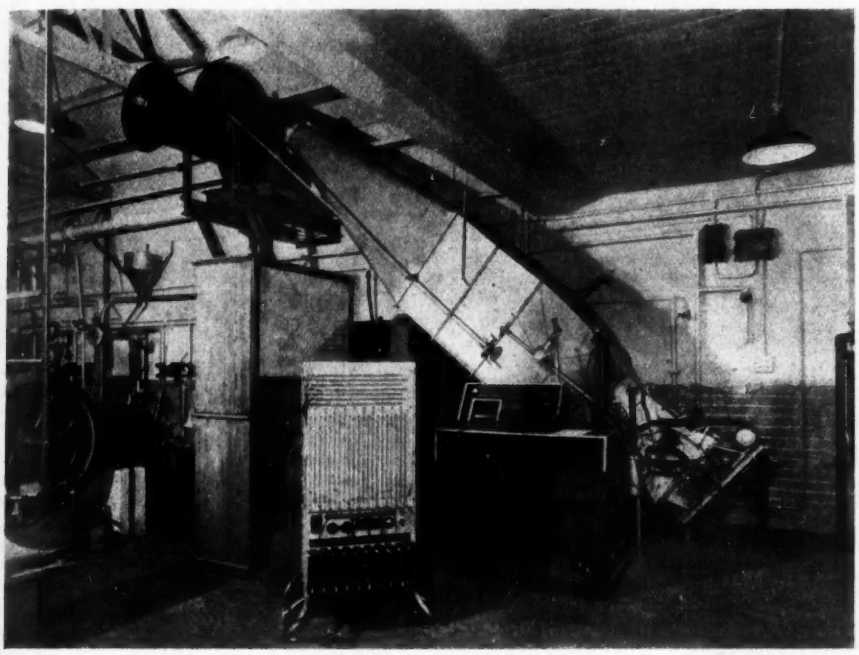
The large project would certainly have taken at least six years to plan and complete, and during that period the intake of applied science students would have had to be reduced. This seemed contrary to the national interest, and, therefore, it was decided to proceed with the smaller project, which has been completed in a little over two years. During this time the student numbers have been maintained and very active research schools developed.

The immediate extra accommodation available represents an increase of some 60 per cent, and when the rooms, at present loaned to the arts faculty, are available, the total increase of accommodation will be 80 per cent.

With the present total accommodation available the intake of students has been fixed at twenty mechanical, twenty civil, twenty electrical, twenty mining and ten metallurgy students per year.

Convertible Timber Furniture

Examples of Duplicated Equipment



Heat Transfer Research Rig

The Soil Mechanics Laboratory

The new extensions have brought the development of civil engineering and mechanical engineering into line with that existing for electrical engineering and mining engineering, and have enabled a sub-department of metallurgy to be formed. It has also enabled the student members to be stabilised at approximately their 1950 level.

The use of convertible timber furniture has been largely instrumental in conserving space, and with it one room is made to serve as the drawing-office and the lecture room or work room for a particular year. The same room can also be used as a laboratory for such of the experiments as do not require water or gas at each station. This prototype furniture, which has been designed by the staff, can be seen in one of our illustrations. It may be noted that alternate forms have hinged tops, which for normal lecture purposes form the writing table for those seated immediately behind. When the room is required as a drawing-office each alternate top is swung over to form a solid table with the fixed lid in front, and on which the drawing boards are placed. Each form contains adequate locker space.

Fundamental to this project is its aim of keeping the laboratory programme in phase with the lecture programme so that, working in small groups, all students complete an experiment simultaneously and with the least possible period elapsing following the lecture associated with it. However, much of the equipment associated with the classical principles of engineering is bulky and normally its duplication on a scale demanded by such a programme would prove impracticable from space factors, if not from economic ones. A new approach to the demonstration of many theorems was required and much ingenuity was apparent in some of the equipment developed, particularly that associated with the demonstration of fluid dynamic principles.

Some typical examples of the apparatus in the various laboratories of the engineering department may be seen in the accompanying illustrations. The heat transfer research rig in the illustration opposite is in the heat engines laboratory and is being used to determine heat transfer to gas turbine blading. The soil mechanics laboratory is also shown. The laboratories also include a research laboratory, in which four major research projects are at present in progress.

Another of our illustrations shows a corner of a laboratory devoted to fluid dynamics and shows some duplicated apparatus. Above each station can be seen a static header tank besides the normal town supply head, which is also available. The scale effect in some apparatus constitutes a problem in the convenient duplication of equipment. Equipment for measuring flow past notches and weirs may be noted from the equipment shown, amongst other items designed for duplication, on the table in the foreground of the illustration. Its short length has been made practicable by arranging the incoming water to pass through multiple holes drilled in three blind vertical tubes at one end of the tank. The resulting water surface obtained throughout the tank was stated to have almost mirror-like properties.

A Works Producer Gas Unit

A SINGLE unit mechanical gas producer and gas cleaning and purification equipment was recently installed at the Luton works of Vauxhall Motors, Ltd., by the Power Gas Corporation, Ltd. It forms an extension to an existing three-unit producer plant of 300,000 cubic feet per hour capacity installed during the last war. The plant gasifies bituminous non-coking coals and generates cold and clean producer gas, which is used for the firing of various ovens and furnaces. It has a rated output of 100,000 cubic feet per hour, the gas producer having an average calorific value of 170 B.Th.U.s gross per cubic foot. The gas is cleaned and purified to less than 1 grain of dust and tar and less than 5 grains of hydrogen sulphide per 100 cubic feet.

Fuel for the producer is elevated by means of a push-button controlled automatic skip-hoist from a ground level hopper to an overhead storage bunker, from which it is charged into the producer by a hand operated fuel charging hopper.

The tars formed are mobile in character and and provide no great difficulty in their subsequent removal from the producer gas. Low gas outlet temperatures are obtained by the efficient heat exchange which takes place in the fuel bed. All the steam required for saturation of the air blast is generated in the vaporiser jacket of the gas producer.

At the bottom of the producer, ash is mechanically and continuously discharged from the water-sealed ash bowl by the action of the revolving grate table which forces the ash against a fixed plough. The ash falls down a chute into wagons or barrows for subsequent disposal. The grate of heat-resisting iron and the table which supports it are mounted on conical rollers and driven by a friction drive unit.

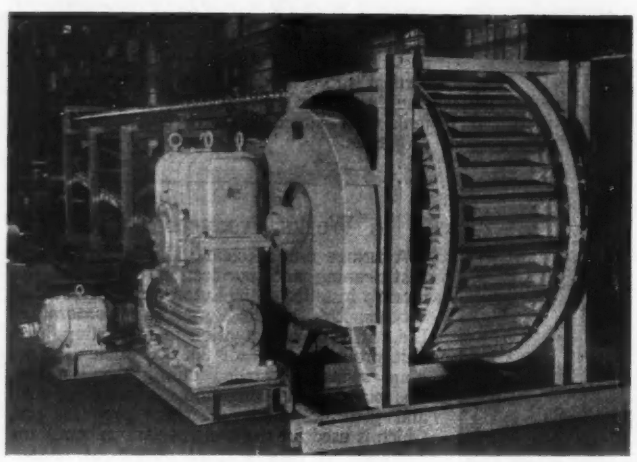
The producer gas immediately after leaving the generator is washed by water in the dust-washer, where most of the dust is precipitated with only a little of the tar. The gas passes on into a centrifugal gas cleaner where most of the entrained tar is removed, the tar recovered from this plant being used in the raising of steam in the boiler house.

Hydrogen sulphide is, for many processes involving heat treatment, deleterious to the products manufactured and is removed in two stages. The first stage or "wet" purification is carried out in a gas washer-cooler and final centrifugal cleaner, where, instead of cold water, a weak alkaline liquor solution is circulated. The second stage or "dry" purification is carried out in boxes packed with a mixture of iron oxide and wood chips—the life of the filling being some seven or eight months. The temperature and moisture content of the gas entering the purifiers is controlled by the addition of steam, to provide the optimum conditions for purification. Dry scrubbers preceding the purifier boxes are packed with a suitable filtering medium, which effects the final removal of tar mist and entrained water. After passing through the purifier boxes the cooled, cleaned and purified producer gas is passed at a pressure of approximately 35in w.g. into the gas mains for distribution in the works.

A Continuous Lead Casting Machine

THE accompanying illustration shows a continuous lead casting machine recently built and installed at a works in Cheshire by the Fraser and Chalmers Engineering Works of the General Electric Company, Ltd. It has a capacity of 10 tons of material an hour in the form of 56 lb pigs.

The machine has a sectional steel framework



Lead Pig Casting Machine

carrying the driving sprockets and supporting the rails upon which the moulds run. The distance between the centre of the main driving sprocket and the centre of the radius at the discharge end rails is 28ft. Each of the eighty-eight moulds has a capacity of 1 cwt in two pigs, and these moulds form a continuous train around the track of the machine, except for a space at the discharge end, where, by means of gravity and a slight bumping effect, the solidified pig is discharged.

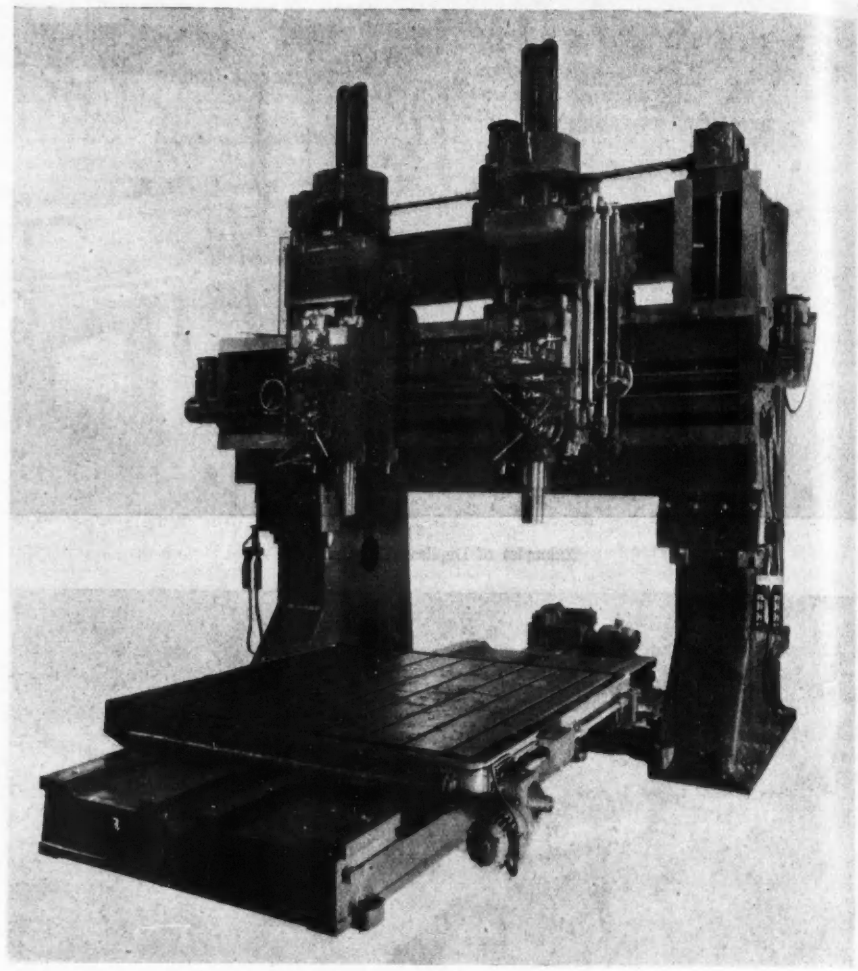
The moulds are not connected to one another, and each travels upon four bushed track rollers.

The drive consists of a 5 h.p. motor driving two double worm reduction gears in a box mounted on a fabricated mild steel bedplate. The gearbox output shaft is fitted with a pinion driving a spur gear wheel which is, in turn, coupled to a driving sprocket, the teeth of which engage the inner side of the mould track rollers.

As the sprocket teeth engage the track rollers at the drive end they traverse the moulds around the inner radius of the slide rails, the actual drive being transmitted by each mould pushing against the preceding mould.

Lead is poured into the moulds at a temperature of 400 deg. to 420 deg. Cent., and contraction of the lead during its cooling period assists discharge. Pigs are ejected with the moulds in a vertical position, ejection being assisted by each mould bumping the preceding mould. After discharge the moulds are returned by gravity along the lower rack to the feed end of the machine.

A running speed of 2·52ft per minute gives the machine a designed capacity of 400 pigs per hour. This time cycle allows ample time for cooling and enables the pigs to be ejected in the solid state. Any dressing which the moulds may need can be effected during the return run to the drive sprocket.



Drilling, Boring and Screwing Machine

A Large Duplex Drilling, Boring and Screwing Machine

A PHOTOGRAPH we reproduce on this page shows a large duplex drilling, boring and screwing machine which has recently been supplied by Kitchen and Wade, Ltd., of Halifax, for machining operations on turbine body steel castings.

On this machine the two independent heads are made right- and left-hand to give a minimum centre distance of 2ft 10in and a maximum of 10ft. Each of the heads is driven by a 15 h.p. motor through an eighteen-speed gearbox giving a spindle speed range from 10 to 300 r.p.m. The spindle is bored No. 7 Morse taper. An interesting point in the design is the incorporation of a range of screwing lead feeds in addition to the drilling feeds. These leads cover from four to twelve threads per inch and with them holes from 2¼in. to 8in diameter can be threaded with a specially designed single-point tool. Spindle rotation is controlled by forward and reverse friction clutches and automatic trip gear is fitted for depth control purposes.

The depth of spindle feed is 27in, means of quick adjustment being provided through four levers on the front of each head. A fine feed handwheel is set at the lower side of each head, and sideways movements along the cross rail are through either power or fine hand motions. This cross rail has a vertical adjustment by power of 4 ft.

The table, which is 10ft long by 10ft wide, is power operated, a quick traverse motion being used initially to bring the work to the spindles, and then a slow traverse of 3in per minute is engaged for final positioning. Duplex pendant push button controls are fitted.

Germanium and the Transistor

(By our American Correspondent)

THE growing application which the germanium transistor device is finding in American electronic equipment of both a military and a civilian kind, was perhaps the most significant development to be observed at the annual meeting and exhibition held by the Institute of Radio Engineers in New York during the week of March 23rd. Several manufacturers displayed battery-operated portable wireless sets and hearing aids, which have been completely "transistorised" and contain no vacuum valves at all. The considerable space savings made possible by the use of transistors was illustrated by various designs of portable communications equipment developed for the armed forces. In his address before the annual dinner of the Institute, General David Sarnoff, the Chairman of the Radio Corporation of America, remarked upon the great changes likely to occur in industry in the near future as a result of the recent developments in this field of solid-state electronics. Just as the vacuum valve is approaching its fiftieth anniversary, it is being confronted by the transistor as its first important competitor.

Due to its use in the manufacture of transistors, and also, more recently, because of its employment in the power rectifier field, much attention is being given to the extraction and purification of germanium. This semi-conductor material in America to-day still costs as much as 350 dollars per pound; but, fortunately, only a small flake of germanium dioxide costing less than one cent is needed in the production of each individual transistor. The great advantages of the transistor are low cost, long life, ruggedness, reliability, compactness, stability, instant starting, and the need for far less current or power than is required by the vacuum valve. Considering all of these significant factors, the broad application of transistors is thought to be almost unlimited in wireless sets, telephone circuits, electronic computers, hearing aids, aircraft, guided missiles and other military apparatus. Thus, in guided missile work, the occasional failure of a valve has been a serious handicap. The transistor is expected to eliminate this type of abortive action. It has already been used in the construction of a battery-operated portable television set having a 4in cathode-ray tube, and it may well be the answer to the "Dick Tracy" wrist watch radio of the American comic strips! Each of the six million television sets expected to be produced in the United States this year will probably contain a few transistors. About forty companies are now working with or producing the devices. The Remington Rand electronic computer control unit weighing about 10 tons and containing 4500 valves, might have been constructed much smaller if germanium transistors had been available at the time. The transistor is believed likely to replace the wireless valve in very many such applications. If it does, there will be a big market, because the sale of valves in America shows a rising annual trend—last year it amounted to 368,500,000 units valued at nearly 260,000,000 dollars.

Unlike the ash of British coal, the ash of most American coal has a relatively low germanium content. Up to the present the chief American source for the metal has, therefore, been the flue dust resulting from zinc smelting. Nevertheless, because of the importance of an adequate supply of germanium from a defence point of view, a strong appeal is currently being made to the American coal industry to co-operate in the "prospecting" for additional sources. The rapid development of the transistor within the last five years from a mere laboratory curiosity to an important tool in electronic engineering has created such interest in germanium that to-day many of the larger American producers of non-ferrous metals are already making efforts to extract the metal as a by-product in their smelting plants. Thus far, there has been admirable co-operation between Government agencies and industry in the field; the U.S. Bureau of Mines is actively promoting the production of germanium while the U.S. Army Signal Corps and the U.S. Air Force are conducting research in the application of transistors to communications equipment. Because so many of the uses of transistors are still at an early stage, it is difficult to predict the ultimate annual demands for germanium. Though still a minor metal to-day, it may well follow in the footsteps of titanium, tantalum and zirconium, which are all growing in importance on account of their particular applications in the fields of aircraft production, corrosion resistance and atomic energy, respectively. The pioneers of wireless telegraphy and telephony indeed have a right to smile to-day, when they see the communications industry returning to the crystal detector stage via the transistor. These new speck-like crystals not only detect, but amplify and oscillate—an idea that would have seemed fantastic at the turn of the century!

American Engineering News

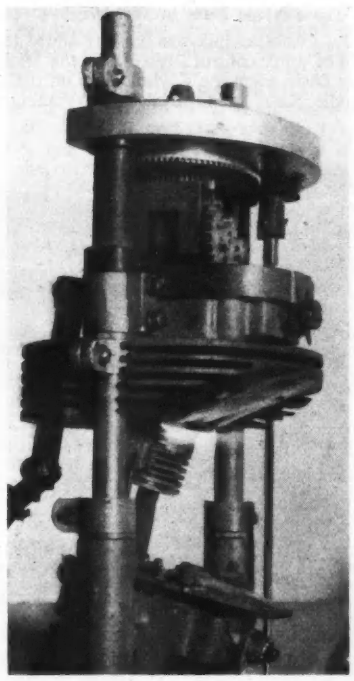
(By Our American Correspondent)

An Automatic Focusing Device for Carbon Arc Searchlights

An automatic focusing device, which has been found to improve the reliability of naval aircraft searchlights, has recently been developed at the National Bureau of Standards, Washington, D.C., as part of an intensive development programme sponsored by the U.S. Navy Bureau of Aeronautics, to improve all lighting equipment used on naval aircraft. In the past, the carbon arc lamp has been used almost exclusively in high-intensity searchlights because of its extremely high luminance. Since the carbons used in such lamps are consumed at an appreciable rate, it has been necessary to develop elaborate mechanisms to ensure stable operation of the lighting equipment. Usually, such mechanisms are required to effect the striking of the arc when the lamp is turned on, to maintain an arc of correct length and to maintain the tip of the positive carbon at the focal point of the optical system. Generally, three methods have been used to position the tip of the positive carbon at the focal point of the mirror or lens. In the first one, the feed rate of the mechanism driving the positive carbon is adjusted so that it equals the burning rate of the carbon, thus keeping the tip stationary. This is satisfactory where an operator is available to make such an adjustment and to correct it as required by slight differences between carbons or in different parts of the same carbon or by slightly changed operating conditions. In most military applications, and especially where the searchlight is mounted at the end of an aircraft wing, this method is impractical and a fully automatic unit is essential.

In the second method of focus control, an image of the positive carbon tip is projected by a small lens or mirror on to a suitable sensing element such as a bi-metallic strip or a photo-electric cell. The optical system is such that, as the positive carbon burns, the image traverses the sensing element. By proper arrangement of the sensing element and its associated circuits, the feed of the carbon thus can be adjusted always to restore the carbon to its correct position. Such devices have been used extensively, and one of them has been employed on the anti-submarine warfare searchlight of the U.S. Navy. As far as the latter is concerned, it was found that if a heat-sensing element such as a bi-metal is used, there is usually considerable thermal inertia, leading to troublesome operation when the equipment is to be used for only short periods of time. In anti-submarine warfare, the searchlight is used for a maximum of half a minute in any one operation, and, frequently, runs may be much shorter. In any event, the optical system and the sensing elements must be carefully adjusted and kept in adjustment. Under the rigorous conditions in which the anti-submarine warfare searchlight is used, the focusing system has thus been one of the chief sources of trouble.

The third method of focus control, known as probe control, is based on a device which senses the position of the positive tail flame of the arc. The tail flame is fairly well defined, particularly in the region close to the carbon, and is fixed in position with respect to the tip of the positive carbon. It is also highly ionised and has fairly steep voltage gradients at its boundaries. Thus, the position of the tail flame and, consequently, of the tip of the carbon, may



Automatic Focusing Device for Anti-Submarine Warfare Searchlight

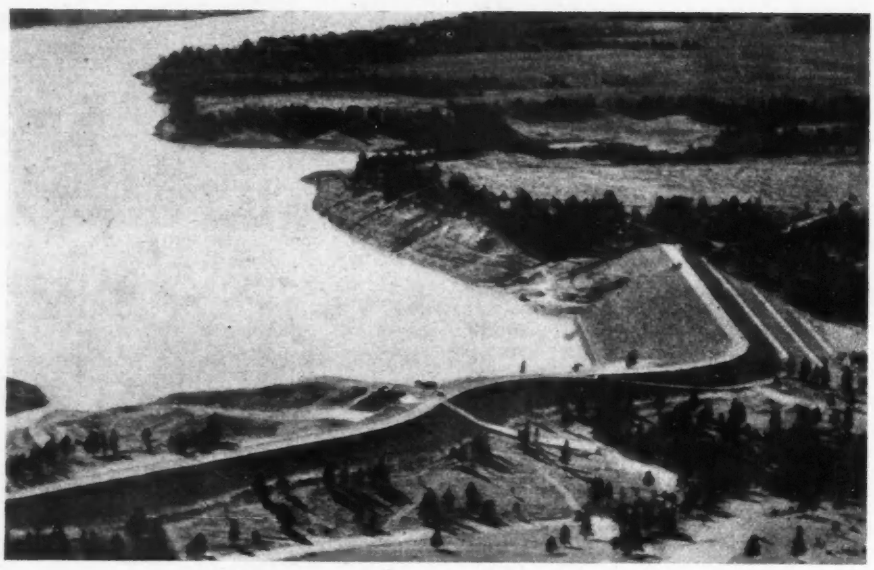
be sensed readily by a "probe" of a suitable conductive material placed near an edge of the tail flame. Ample energy is available in this vicinity to operate a conventional relay of moderate sensitivity. As used in the past, probes for this purpose have generally been rods of highly refractory conductive material, such as tungsten or carbon. While excellent focus control was attained, it was found that all of the materials used tended eventually to melt, evaporate, or burn away. It was thus necessary to replace the probes periodically and to check the adjustment frequently. In the modification of the anti-submarine warfare searchlight developed at the N.B.S., a probe control is used in place of a thermostat optical system, but it is designed in such a way as to avoid any tendency to deteriorate from the heat of the adjacent arc and to eliminate any need for maintenance or adjustment. Instead of refractory materials for the probe, copper of the highest practicable thermal conductivity is used, as it is intended to conduct the heat away as rapidly as possible, rather than to attempt to find a probe material which could withstand the high temperatures. In addition to being made of highly conductive materials, the probe is designed with considerable bulk, which permits heat flow in three dimensions. Conventional probes of refractory rods of low thermal conductivity do not allow the heat to flow away from the tip rapidly; therefore,

extremely high temperatures are reached. As shown in the accompanying illustration, the final form of the new probe is that of a thick disc electrically insulated from the remainder of the positive carbon drive mechanism. The positive carbon feeds through a hole in the centre of the disc. The upper edge of a recess, which is milled out of the front edge of the disc, serves as the effective probe tip. Finally, the massive probe acts as an obturator, or barrier, helping to shield the positive drive mechanism from the radiant heat of the arc. The control system of the Bureau has been found to have practically no thermal inertia and to function satisfactorily for the brief periods encountered in anti-submarine warfare. Since it is permanently and rigidly attached to the positive head mechanism, there are no adjustments to make and there is no danger of disturbing any adjustment. It is not easily damaged or rendered inoperative by mechanical shock, vibration, dirt, corrosion or other environmental conditions that may interfere with the operation of thermostat optical or photo-electric optical systems.

The Keyhole Dam in Wyoming

Another link was recently added to the chain of water control structures in the Missouri River Basin when the Keyhole dam on the Belle Fourche River in north-eastern Wyoming was completed. This earth-fill structure, which is shown in the accompanying illustration, is the eleventh dam completed by the U.S. Bureau of Reclamation under the Missouri River Basin scheme. By means of controlled releases, the dam will augment and stabilise the diversions to the existing Belle Fourche irrigation project farther downstream in South Dakota, which has been operating with an insufficient water supply in the past. When released into the river, the water impounded by the dam will be diverted by the Belle Fourche Diversion dam, 152 miles downstream and will be delivered to the Belle Fourche reservoir through a 6½-mile feeder canal.

The Keyhole dam site controls 1910 square miles of catchment area. The structure, which is 168ft high and 3420ft long, will perform the functions of a multi-purpose unit, providing supplemental water for irrigating nearly 55,000 acres, flood protection along the Belle Fourche River in Wyoming and South Dakota, and other benefits such as silt control, pollution abatement, fish and wild life conservation, recreational use and providing a water supply for municipal and industrial use at the city of Belle Fourche. The reservoir behind the dam lies in the bottom land of a rough western landscape, on the flank of the Black Hills. About 130,000 acre-feet of water is impounded in the reservoir as conservation storage, 70,000 acre-feet is allowed for silt control, and 140,000 acre-feet will be held open for flood control, making the total capacity 340,000 acre-feet, with an additional 288,400 acre-foot capacity for emergency storage. At full pool, the reservoir has been designed to be about 9 miles long and 5 miles wide. The dam structure includes an open channel, uncontrolled spillway at the right abutment and a tunnel outlet works through the left abutment. The centre portion of the dam consists of moistened and rolled clay, sand and gravel. The upstream portion is protected by riprap placed over a layer of gravel, and the downstream slope is covered with 12in of top soil.



Keyhole Dam and Reservoir

Variable Swept Wing Jet Aircraft

The U.S. Navy has cancelled contracts for the construction of 100 "F-10-F" "Jaguar" jet fighter aircraft that were to have been built by the Grumman Aircraft Engineering Corporation of Bethpage, New York. The "Jaguar" was one of the first American combat aeroplanes to be built with variable-sweep wings. The design of the "Jaguar" made it possible for the position of the wings to be changed in flight, permitting them to be in a straight position after take-off and swept back at high altitudes. Rear-Admiral T. S. Combs, chief of the Bureau of Aeronautics, U.S. Navy, has stated that the Navy remained interested in variable sweep wings but that it had become apparent that so many designs and configuration changes were necessary in the aircraft that delivery would have been long delayed. The Grumman Aircraft Engineering Corporation announced that its designers would continue to develop the variable swept wing principle.

Overhaul Life of the "Avon" Turbo-Jet Engine

Some assuring indications of the life of turbo-jet engines under operational conditions have been revealed from an intensive flying programme now concluded by the Royal Air Force. This programme was carried out to determine the ultimate overhaul life of the Rolls-Royce "Avon" engine of the latest modification standard, and also to provide a "yard-stick" by which to assess R.A.F. requirements in respect of personnel and facilities for maintaining and overhauling the latest jet engines. High priority was given to this operation by R.A.F. stations at Binbrook, Upwood and Hemswell, crews being allocated exclusively to the "Canberra" aircraft to get the flying time in as quickly as possible.

Of the six "Avons" concerned, two were examined at 400 hours and one at 450 hours. As their strip condition proved satisfactory a decision was taken to continue flying the remaining three engines to an overhaul life of 600 hours.

Binbrook has the distinction of being the first R.A.F. station to fly an "Avon" for 600 hours. This time was completed in fifty actual days in which time some 300,000 miles were flown, or the equivalent of fifty daily journeys across the Atlantic and back. The average utilisation was twelve hours per day.

The turn-round time for the aircraft improved tremendously as the trial progressed. The average turn-round for the first month was one hour thirty-five minutes. For the second month it was one hour ten minutes and for the third month thirty-six minutes—on one occasion one aircraft landed, was serviced, and took off again in thirty minutes.

During one period four or five aircrews operated "round-the-clock," flying as many as twenty-two hours in twenty-four. The peak utilisation was reached when seventy-three hours were flown in a period of eighty-four hours.

As will be apparent, maintenance during flying was negligible and the performance of the engine was still acceptable to the Rolls-Royce production schedule at the end of the 600-hour period. Comparative figures for engine performance showed that the thrust output was still within 3 per cent of the standard figure and the increase in specific fuel consumption was as low as 0·11 per cent.

Following the stripping and examination the only parts which were rejected were four compressor rotor blades, two auxiliary drive roller bearings, two auxiliary drive oil seals, two flexible fuel pipes and two compressor shaft taper bolts.

The flame tubes, which are the commonest cause of "short life" on gas turbine engines, were only slightly affected and all have been accepted for a further service life of 400 hours. The turbine was found to be satisfactory in every respect.

Rolls-Royce, Ltd., maintains that this test sets a new standard of low cost maintenance which will be of interest to both military and civil airline operators.

It is interesting to note how favourably the aircraft jet engine now compares with other forms of transport on a basis of miles operated between overhauls. Six hundred hours represents a distance covered of 300,000 miles between overhauls. This compares with the 100,000 miles worked by a railway locomotive or commercial road vehicle.

A 40ft Span Precast Concrete Roof

We are informed by Concrete, Ltd., 16, Northumberland Avenue, London, W.C.2, that a roof with a clear span of 40ft 9in has recently been built for a gymnasium at Chiswick Polytechnic; it consists of hollow precast prestressed concrete units. The units are 42ft 4in long, 8½in deep at the ends, increasing to 10½in in the middle, and 14in wide. The cavity is approximately 9½in wide and 5½in deep at the ends, increasing to 6½in deep in the middle. The overall weight of these units is 68 lb per square foot, and they are designed to carry "finishes" of 28 lb per square foot plus a loading of 25 lb per square foot, which provides for a possible roof loading and for a considerable number of hangers for gymnasium ropes. All these units are normal prestressed "Bison" slabs, each reinforced with fourteen 0·2in diameter high-tensile wires; when grouted, the units form a rigid roof, the makers state, with no sign of the exceptional springiness which might be expected with such a shallow slab. The actual units were tested in the factory with a load equivalent to the finished dead load plus twice the superimposed load without any sign of cracking, and deflection under the design load of 25 lb per square foot was 0·435in, or under one eleven-hundredth part of the span. They were erected with a mobile crane, which, despite difficulty of access, enabled the entire area of 330 yards super to be completed in under a week.

Industrial and Labour Notes

Britain's Overseas Trade

The monthly accounts published by the Board of Trade put the final figure of exports of United Kingdom goods in March at £212,900,000, or about 3 per cent above the average for the first two months of this year, and nearly equal to the monthly average in the fourth quarter of last year. Imports in March were valued at £285,700,000 and re-exports at £10,900,000, so that the excess of imports over total exports was £62,000,000.

The Board of Trade says that in the first quarter of this year as a whole exports were at the rate of £208,500,000 a month, which was 2 per cent below the average in the preceding quarter. Export prices appear to have weakened slightly, but as yet no marked change has been recorded from the price level in the preceding quarter. Although the volume index numbers are not yet available, the Board of Trade thinks it likely that the volume of exports in the first quarter was very little less than in the fourth quarter of last year.

Exports of engineering products in the first quarter of this year reached a value of nearly £83,000,000 a month, which was £1,000,000 below the monthly average in the fourth quarter of last year. The reduction was in shipments of machinery, the value of which declined to about £34,000,000 a month. The Board of Trade figures show that shipments of vehicles—excluding tyres and tubes—were almost unchanged at £35,000,000 a month, as were exports of electrical goods and apparatus, which were valued at £9,000,000 a month. There was some recovery during the first quarter in certain sections of exports of vehicles, but it was offset by reductions in other parts of the group. Compared with the final quarter of last year, there was an increase of about 10 per cent in the number of cars and chassis exported, and the number of agricultural tractors probably increased by a similar proportion, but the number of commercial vehicles and chassis declined by 3 per cent. Exports of metals and manufactures thereof in the first quarter of the year amounted to £24,000,000 a month, or about 4 per cent less than in the fourth quarter of 1952. The whole of the reduction was in iron and steel and manufactures thereof, which decreased 5 per cent to £17,000,000 a month from the high figures reached in the fourth quarter of last year. Among exports of non-ferrous metals, the value of which averaged £7,000,000 a month in the first quarter of this year, the quantity of copper increased by 47 per cent and aluminium by 12 per cent.

The National Joint Advisory Council

The quarterly meeting of the National Joint Advisory Council was held in London on Wednesday of last week, under the chairmanship of the Minister of Labour, Sir Walter Monckton. According to a statement which was issued after the meeting, one of the matters discussed was a review of training and apprenticeship arrangements, following an inquiry addressed by the Ministry of Labour to seven selected industries rather more than a year ago.

In January of last year, the Council recommended that certain industries should be asked to examine their apprenticeship schemes and consider whether the scope of their training arrangements could be widened ; whether the period of training could be shortened and the minimum age of entry into apprenticeship lowered ; whether the present upper age limits could either be removed or modified to allow older workers, who had shown themselves potentially suitable, to be accepted as craft apprentices, and whether, given intensive methods, workers could be trained for a wider range of employment. In addition, industries were to be asked to examine their schemes for the selection and training of supervisors. It was the replies received to an inquiry of this nature that the Council considered last Wednesday. Those replies, it was stated, indicated satisfaction with the existing training arrangements. The Council expressed some disappointment with the results of the inquiry and recommended that the Ministry of Labour should keep the matter under review.

Training for Industry

Speaking at the annual Cutlers' Feast, in Sheffield, on Tuesday of last week, the Minister of Labour, Sir Walter Monckton, emphasised the need to maintain a high standard of quality and a high rate of production in this country's industries. Those objectives, he said, were essential to enable the country to compete in the markets of the world.

Nothing was more important in striving for those objectives, Sir Walter continued, than to make the best use of manpower resources. In order to do that, all those engaged in industry, employers and workpeople alike, needed to have the right attitude to production, and to be properly and adequately trained. Furthermore, the establishment of good human relationships was essential. Sir Walter went on to urge that the training of the youth of this country was all important at the present time, because young persons were much scarcer than they used to be. Compared with 1939, there had been a fall of nearly 10 per cent in the number of boys and girls reaching the school-leaving age. During the next three years, there would be a further fall. For the following five years there would be an appreciable improvement, after which there would again be a sharp fall.

It was essential to the country's economic and social well-being, Sir Walter said, that every youth should be properly educated and adequately trained. Education must not stop when a boy or girl left school. The training of a new entrant into industry in the technique of the job was accepted as the responsibility of the employers, and it should be the aim of every employer to give a proper degree of training to every boy and girl who entered his employment. But that, Sir Walter suggested, was not sufficient ; education must go on, and it was industry's responsibility to see that the education of young people did not cease when they entered the workshop. In that matter, he thought, industry could take the initiative and make suitable arrangements with the education authorities.

European Steel Production

The United Nations Economic Commission for Europe has published, this week, its *Quarterly Bulletin of Steel Statistics*. Therein it is shown that crude steel production in Europe as a whole (excluding the U.S.S.R.) continued to rise during the first two months of this year, though the increase was not evenly spread over all the countries. In January the production of crude steel, in the countries of Europe reporting to the Commission, was at an annual rate of 67,684,000 metric tons, compared with a total production last year of 63,359,000 metric tons. During February, however, steel output in France, Belgium, Luxembourg, Italy and the Saar was lower than in January.

Three new sets of tables have been included in this issue of the *Bulletin*. The first shows in some detail the deliveries of different finished steel products by consuming industries for the year 1951 and, in some cases, for the first nine months of 1952. The tables in this section deal with five countries—the United Kingdom, Belgium, France, Western Germany and Luxembourg—which together accounted for approximately 48 per cent of European steel consumption in 1951. The second new section shows the products which made up the total of the 2,200,000 tons of steel coming from new continuous wide-strip mills in 1951, and the third set of new tables gives an analysis of the descriptions and destinations of the scrap returning to the steel industry through the hands of merchants.

Steel Plate Distribution

The Minister of Supply, Mr. Duncan Sandys, was asked in Parliament last Monday to indicate the priorities and general lines upon which the new steel plate distribution scheme was to operate. In a written answer, the Minister said that he was asking the steel plate makers to allot a somewhat larger proportion of the available supplies to shipbuilders and to certain important sections of the engineering industries. That would be facilitated by the increased supplies of plate which were now coming forward. In addition, the reply explained, the newly-appointed inter-departmental committee was to be asked to arrange with the producers for adjustments in deliveries to individual consumers.

Industrial Production in Northern Ireland

The Government of Northern Ireland has stated within the last few days that the 1951 census of industrial production is nearly complete. An interim report indicates that the gross output in 1951 in all branches of industry in Northern Ireland (excluding small firms employing ten people or less) was £333 million, compared with £284 million in 1950 and with £60,000,000 in 1935. It should be noted, however, that in the 1951 census, firms engaged in mining and quarrying were excluded. They were employing about 2800 people and their gross output has been estimated as £1,250,000. Another interesting point mentioned in the interim report is that the cost of the materials used in the industries included in the census was £234 million in 1951, compared with £38,359,000 in 1935, and that in the period between those years the average number of people employed rose from 140,176 to 211,400. Firms and public utility undertakings recorded a total expenditure on plant, machinery and vehicles of £7,900,000 in 1951, compared with £10,150,000 in 1950. The capital expenditure on new building and other constructional work in 1951 was £2,160,000, compared with £2,950,000 in 1950.

Taxation and the Shipping Industry

The annual report and accounts of the Cunard Steam-Ship Company have now been issued. They are accompanied by a statement by the chairman, Mr. F. A. Bates, in the course of which reference is made to the effect of current taxation upon the shipping industry.

The statement says that the allowance permitted to be set off against the tax computation of profits provides an insufficient money total each year to pay for the renewal of ships as they wear out. The result of this too small allowance is simply to swell the taxable computation and to take away as tax some part of receipts which should by every provident standard be retained for fleet renewal. This, Mr. Bates comments, is a grave matter for this country—an island with limited acres and a growing population—and particularly is it grave for the shipping industry if over-taxation of current profits brings to an end the continuing renewal of the ships in every class of British trade, including the tramps.

Mr. Bates considers it to be clear beyond all doubts, from the pronouncements of shipping authorities, that the future of our tonnage is already being endangered by the impossibility of setting aside enough money to provide for the heavy costs of replacement under current conditions in the shipbuilding yards. To spend in taxes money that should be replacing the hulls and engines, augmenting the fleets, and conducting the commerce by which an island lives is far worse, the statement says, than just going to sleep and letting the cakes burn !

Coal Output

Coal production in Great Britain last week amounted to 4,696,700 tons, of which 4,457,900 tons came from the deep mines and 238,800 tons from opencast workings. In the first sixteen completed weeks of this year, the total saleable output of coal has amounted to 72,198,100 tons, which is about 524,000 tons more than in the corresponding period of last year. The latest figures available concerning mining manpower show that in the week ended April 18th there were 721,400 wage earners on colliery books, of whom 300,400 were face workers. A year ago the number of face workers was 290,500. There has been in recent weeks a slight increase in the output per manshift at the face, the latest figure being 3·18 tons. Distributed coal stocks on April 18th amounted to 12,355,000 tons.

Notes and Memoranda

Rail and Road

LOCOMOTIVES FOR NIGERIA.—An order has been placed with the Hunslet Engine Company, Ltd., by the Nigerian Railways for six 3ft 6in gauge 0–8–0 tender-tank locomotives. This design of locomotive is a special combination for the Nigerian railways and is intended to allow otherwise standard shunting locomotives to operate over longer distances or for longer periods. The locomotives are of the standard 48½-ton, 18in by 23in cylinder, 0–8–0T design, many of which have been built by the company. The side tank is retained, but the bunker is cut off and the cab altered. A six-wheel tender having a water capacity of 4000 gallons has been added, giving a total of 5000 gallons for the combination.

A NEW WATER COLUMN.—A new design of water column for filling the tanks of locomotives, which is being tried out by British Railways, is easier to handle, more economical in use, avoids waste of water, and is frostproof. A long counterbalanced aluminium pipe arm at the top of the column can be swung round to any point and the tip depressed over the engine tank with one hand. The weight of the water running in from the main holds the top of the arm down, and when the water is turned off the arm rises and any water it contains drains back into the supply pipe. The water valve is set below ground level so that in cold weather the column is unaffected by frost. Brasiers and soakaways, normally provided with the existing type of water column, will therefore be unnecessary. The first of the new columns are in use at a number of motive power depots and others will be installed if experience in service shows them to be entirely satisfactory.

VEHICLE EXPORTS.—The Society of Motor Manufacturers and Traders has announced that the latest export figures show further gains by the motor industry. In March car shipments rose to almost 25,000 (24,887), nearly 4000 more than the average for the first two months of the year. Commercial vehicle exports at more than 9000 (9,242) showed a rise of over 600 (653) on the same comparison, while nearly 9000 (8801) agricultural tractors beat the previous monthly rate so far this year by 1700 (1703). Car exports over the first quarter of 1953 as a whole showed a considerable increase in dollar sales when compared with the first three months of last year. Sales of British models to the U.S.A. more than doubled at little short of 10,000 and the 5300 (5323) sent to Canada was almost ten times greater (548). These figures reflect the energetic sales campaign which British manufacturers have been pursuing on the North American Continent.

Air and Water

OIL TANK CLEANING AND GAS FREEING.—The British Wheeler Process, Ltd., has recently published a brochure which deals with the company's tank cleaning and gas freeing system. There is a description of the Wheeler system and of the plant involved, which is installed in a number of special purpose vessels, and operates on the vacuum principle. The brochure is illustrated and photographs show various ships of the company's fleet in operation.

NAVIGATION TO-DAY.—A special exhibition entitled "Navigation To-day," which was opened recently at the Science Museum, Exhibition Road, South Kensington, London, S.W.7, will be on view to the public during May and will remain open until September. By means of diagrams and working models the Exhibition will state the navigator's problems and will show some of the methods and equipment which he uses to solve them. Included in the exhibition will be large-scale models of a ship's bridge and of the flight deck of an aircraft carrier.

AIR ACTIVITY AT UNITED KINGDOM AND CHANNEL ISLANDS AERODROMES, MARCH, 1953.—Air transport movements at United Kingdom aerodromes in March, 1953, numbered 12,100, approximately 5 per cent more than in March, 1952. The total of passengers handled was 189,600, approximately 30 per cent more than in March, 1952. Freight on and off-loaded amounted to 3870 short tons, an increase of 33·5 per cent on the corresponding month of the previous year. Post Office mail set down and picked up during the month decreased slightly from the previous year's figures to 1110 tons.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At a general meeting of the North-East Coast Institution of Engineers and Shipbuilders, held on April 24th, it was announced that Lieut.-Colonel T. Eustace Smith had been elected president and that Mr. J. B. Kerr had been re-elected a vice-president, while the new vice-presidents were Mr. J. Bulman and Mr. A. J. Marr. The new non-associate members of council are Sir Lawrence Edwards, Mr. P. Jackson, Mr. C. Stephenson; while Messrs. W. S. Paulin, W. Turnbull and H. G. Yates had been re-elected, and Mr. J. H. Short, as a result of the ballot, was elected an associate member of council.

LLOYD'S WRECK RETURNS.—The returns of merchant ships totally lost, broken up, &c., for the quarter ended September 30, 1952, has been published by Lloyd's Register of Shipping. Steamships and motorships totally lost consequent upon casualty amounted to 40 ships of 50,730 gross tons, of which 2 ships of 696 tons belonged to Great Britain and Northern Ireland and 7 ships of 8963 tons were owned by the other Commonwealth countries. Of the vessels broken up, &c., not consequent upon casualty the world total was 91 ships of 147,539 gross tons, including 30 ships representing 64,120 tons and 8 ships of 4341 tons owned by Great Britain and Northern Ireland and the other Commonwealth nations respectively.

TRAINING SCHEME FOR MARINE ENGINEERS.—To meet the demand for seagoing engineers, the North Eastern Marine Engineering Company (1938), Ltd., and associated firms have introduced training schemes for apprentices. Arrangements have been made with the educational authorities on the Tyne, Wear and at Hartlepool, for training boys under the "day release" system when they attend school during the day as well as evening classes. Training specially suitable for potential craftsmen has been arranged and some 800 boys will come under the unified system of training. The annual camp in connection with the welfare scheme will form part of the training course, and one object will be an attempt to lay the foundation of a character training course as part of the overall pattern.

TANK CLEANING INSTALLATION.—The Mountstuart Dry Docks, Ltd., has built a large tanker cleaning plant in the Roath Dock, Cardiff, which has been designed to gas-free and clean the tanks of oil tankers after the discharge of their cargoes. The plant is self-contained and consists of a boiler, an oil separator, filter and oil storage tankers, while for washing out the tanks the Butterworth system is used. The oily ballast is pumped ashore and passes through separator and filter plant, the separated oil passing to the storage tanks and the water being discharged into the dock. Both the separator, which is completely enclosed, and the storage tanks are protected by a new fire prevention system, using inert gas. The plant generally complies with the requirements of the Home Office and embodies the recommendations resulting from the investigation into the Avonmouth Oil Depot fire in 1951.

Miscellanea

MEETING OF GEOPHYSICISTS.—The fourth meeting of the European Association of Exploration Geophysicists will be held in Paris on May 20th, when about twenty papers dealing with many phases of geophysical prospecting will be presented.

CONTINUOUS SHIELDED ARC WELDING.—In the article in our issue of April 24th, dealing with the continuous shielded arc welding equipment made by the British Oxygen Company, Ltd., we inadvertently referred to it as "Argonarc" equipment, whereas the firm uses the trade name "Argonaut" for this plant.

COPPER PRICE REDUCED.—The Ministry of Materials has announced that, following negotiations with its main suppliers in the Commonwealth, its selling price for electrolytic copper delivered consumers' works has been reduced from £280 to £253 per ton with effect from April 25th. Discounts and premiums remain unchanged.

RUBBER IN RAILWAY ENGINEERING.—In our issue of November 21, 1952, we gave some notes on a conference dealing with recent French developments in the use of rubber for railways, which was held in London under the auspices of the British Rubber Development Board. A brochure on the proceedings, which has now been published by the board, includes the papers which were read at the meetings and the discussions.

MR. JOHN PARAMOR.—We have learned with regret of the death of Mr. John Paramor, M.I.Mech.E., which occurred at Watford, on April 2nd, at the age of eighty-six. For more than forty years, Mr. Paramor was managing director of the Watford Engineering Works, Ltd., and had been chairman of that company since 1932. In the early years of his engineering career, Mr. Paramor served in the lighthouse department of the Chilean Government.

TAKORADI HARBOUR.—The major constructional works which have been in progress for the past few years at Takoradi harbour on the Gold Coast have now been completed. The harbour extensions were officially opened by the Governor of the Gold Coast on Friday last, April 24th. A description of these works was given in our issue of February 15, 1952. Their total cost was about £3,500,000, the consulting engineers being Messrs. Rendel, Palmer and Tritton, and the contractors Taylor Woodrow (West Africa), Ltd.

RETIREMENT OF MR. W. HANNEFORD-SMITH.—We have been informed by B. T. Batsford, Ltd., that Mr. W. Hanneford-Smith is retiring from active participation in the day-to-day affairs of the business. He has now completed sixty years' service with the firm and is retaining his place on the board. To commemorate his diamond jubilee with the house of Batsford, his fellow directors are presenting Mr. Hanneford-Smith with his portrait painted in oils. Many of our readers will recall that Mr. Hanneford-Smith was joint editor of *Kempe's Engineer's Year Book* for twenty-one years, before that publication was acquired by the proprietors of THE ENGINEER.

AUTOMATIC CONTROL OF OPEN-HEARTH FURNACES.—An article under this title appeared in our issue of March 27th last. It is of interest to note that the measuring instruments for coke-oven gas, combustion air, oil and atomising steam for each open-hearth furnace were supplied by George Kent, Ltd., to Tinsley (Industrial Instruments), Ltd. The coke-oven gas is metered by means of an orifice plate, the differential produced being connected to a ring-balance meter actuating an electrical transmitter. The combustion air is measured by means of an intake cone fitted on to the inlet of the combustion air fan, and the differential produced is again taken to a ring-balance type electrical transmitter. The oil is measured by means of a "PL" orifice plate fitted with sealing chambers, and the differential produced is taken to a "KM" type electrical transmitter. A similar arrangement is made for the measurement of the atomising steam flow.

THE "MECHANICALS'" BENEVOLENT FUND.—The annual general meeting of the Incorporated Benevolent Fund of the Institution of Mechanical Engineers was held in London on Friday last, April 24th. The report of the committee of management stated that in the revenue and expenditure account for the year 1952 there was a small deficit. The total membership of the Fund at the end of last year was 6175, which was fourteen less than at the end of 1951, and, in addition, contributions were received last year from 4115 other members of the Institution. The report said that it was a matter of real concern that such a small percentage of the members of the Institution were members of the Fund. The amount disbursed last year in grants and allowances was £7586, compared with £7307 in the preceding year.

JUNIOR INSTITUTION OF ENGINEERS.—Last Friday, April 24th, the Junior Institution of Engineers held its annual dinner at the Connaught Rooms. The usual customs were observed and the unofficial toastmaster made sure that the president "took wine" with various individuals and groups of members and guests during the service of the meal. Afterwards, there were the formal toasts to be honoured. That of "The Institution" was proposed by Mr. T. E. Goldup, vice-president of the Institution of Electrical Engineers, and Mr. S. R. Broderick, chairman of the Institution, replied. The toast of "The Air and the Future" was proposed by Mr. S. Scott-Hall, Director General of Technical Development (Air), Ministry of Supply, who, in a reference to the increasing length of airport runways, remarked that gas turbine engines may soon develop such thrusts that nearly vertical take-off will become possible, thus permitting a reduction of their length. Air-Commodore F. R. Banks, president of the Institution, replied. In response to the toast of "The Guests," Sir Eric Bowyer, of the Society of British Aircraft Constructors, replied in addition to Mr. O. D. Smith, president of the Maudslay Society. Proceedings were brought to an end when Mr. F. M. Panzetta, vice-chairman of the Institution, proposed the toast of "The Chairman."

INSTITUTION OF CHEMICAL ENGINEERS.—The annual dinner of the Institution of Chemical Engineers was held in London on Thursday, April 23rd, with the president, Mr. Stanley Robson in the chair. Proposing the toast of "The Institution of Chemical Engineers," Lord Percy of Newcastle discussed educational problems related to the training of chemical engineers. Difficulties, he said, existed in the finding of teachers to deal with the subject and another question to be answered was how much extension of the university course could be justified. He contrasted the attitude adopted in America with that in Great Britain and suggested that it was wrong to regard technical education as a single unit operation. In his response, the president said that although the Institution was young it was one of the main engineering societies and was engaged in the study of the fundamental principles of engineering. He commented on the growth of membership from 900 in 1937 to 2900 in 1953, and thought that the strength of the junior section was extremely significant. At the conclusion of his speech, the president presented the Osborne Reynolds Medal to Mr. J. A. Oriel, who later proposed the toast of "The Guests." Chemical engineers, he said, had a prominent place in building up the country's wealth, but he thought that what the industry meant to this country was not appreciated sufficiently. Mr. C. G. Hayman responded.

Personal and Business

MR. J. MEARES has been appointed secretary of Allen West and Co., Ltd., Brighton.

VACUUM OIL COMPANY, Ltd., announces the retirement of Mr. S. W. Day, manager of its Bristol branch.

MAJOR C. J. STEWART and Mr. F. H. Carey have been appointed directors of Dowty Fuel Systems, Ltd., Cheltenham.

MR. H. O. HINTON and Mr. E. Cooper have been appointed directors of A. C. Morrison (Engineers), Ltd., Loughborough.

THE BIBBY LINE, Ltd., announces the retirement of Captain Richard S. Evans, O.B.E., the commodore master of the Bibby Line.

MR. T. W. KENDALL has been appointed sales director, and Mr. P. H. Hylton, marine sales manager, of Ruston and Hornsby, Ltd., Lincoln.

MR. W. B. G. COLLIS has been appointed assistant sales manager of the traction department of Metropolitan-Vickers Electrical Company, Ltd.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its Lincoln branch office has been moved to 113, Canwick Road, Lincoln (telephone, Lincoln 654).

MR. W. R. CLARK LEWIS has retired from his position as traffic manager of Babcock and Wilcox, Ltd., after forty-five years in the company's service.

MR. A. H. KEABLE, M.I.Mech.E., has retired from the office of managing director of Sharples Centrifuges, Ltd., which he has held for twenty-five years. He continues to serve as chairman of the company.

LEYLAND MOTORS, Ltd., has announced the formation of a new company entitled Leyland-Albion (Africa), Ltd. This company is the outcome of an amalgamation of the South African interests of Leyland Motors, Ltd., and Albion Motors, Ltd.

MR. G. N. VANSITTART has relinquished the chairmanship of Vauxhall Motors, Ltd., on being appointed chairman of General Motors, Ltd. Sir Charles Bartlett has been elected chairman of Vauxhall Motors, Ltd., and is succeeded as managing director by Mr. W. E. Hill.

British Patent Specifications

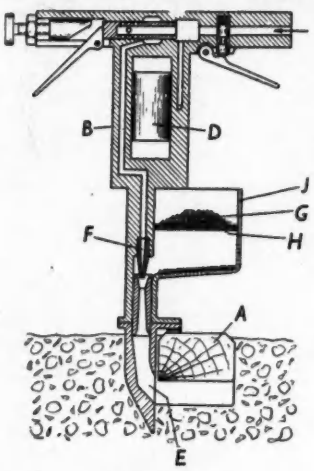
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

RAILWAY ENGINEERING

689,332. October 17, 1950.—PACKING UP RAILWAY SLEEPERS BY INJECTION, Frankfurter Maschinenbau Aktiengesellschaft, Vorm, Pokorny and Wittekind, Solmsstrasse 2–26, Frankfurt a.M., West 13, Germany.

The drawing represents an injection apparatus. According to the invention, the sleeper *A* to be packed is first lifted to the required height. The injection apparatus *B* is then set beside the sleeper, preferably in the vicinity of each of the two rails, and then under the action of the compressed air vibrator *D* it is driven into the bed until the injection orifice *E* has reached the working position.



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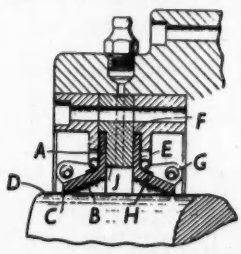
The quantity of air supplied to the vibrator is now considerably reduced, and at the same time the passage to the injection nozzle *F* is opened to the main air supply. In consequence of the now substantially damped shaking movement, the granular bedding material *G* contained above the sieve *H* in the container *J* passes through the sieve openings on to the bottom of the container and thence through the outlet into the injection pipe. Here the individual grains are picked up in the air current coming from the nozzle and projected at a high velocity through the air funnel into the cavity below the sleeper, and at the same time are firmly compacted there, until the sleeper sits firmly on the bed.—*March* 25, 1953.

BEARINGS AND SUPPORTS

689,193. May 20, 1950.—SEALING RINGS FOR SHAFTS, Richard Dutton-Forshaw, Homefield House, Walton-on-the-Hill, Tadworth, Surrey.

The invention is concerned with sealing rings of the larger types, as used, for example, on the necks or trunnions of rolling mill rollers. As shown in the drawing, there are two flexible annular elements, arranged back to back with a metal spacing ring between them. Each flexible element has a flat



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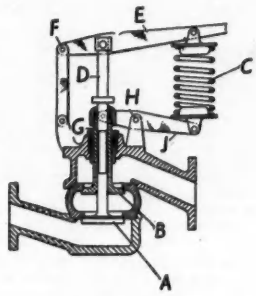
radial portion *A* and an integral inclined portion *B*, terminating in a sharp lip *C*, which, in use, engages the shaft *D* to be sealed. The flat part may be of a harder rubber material than the inclined part, and either or both may be reinforced internally. Placed on the outer edge of the radial portion are a number of wire springs *E*, partially embedded in the rubber, and each of which has a turned-over loop *F* by which it hooks on to the edge of the sealing member. Resting on the inclined portion *B* of the sealing member are a number of fibre shoes *G*, there being one shoe between each two consecutive springs, and the outstanding pins *H* of the springs *E* enter holes in the side faces of the shoes. The springs press the shoes downwards on to the inclined portion of the sealing member. It will be seen that sealing elements are arranged back to back with a metal ring *J* between them. The assembly is sandwiched between two outer metal rings, the whole being bolted together to form a composite sealing unit. Modified designs are also shown in the specification.—*March* 25, 1953.

VALVES

689,372. August 30, 1951.—QUICK-CLOSING SHUT-OFF VALVES, Gustav Friedrich Gerdts, 130, Hemmstrasse, Bremen, Germany.

The invention relates to quick-closing shut-off valves for desludging boilers. Referring to the drawing, in the valve casing is arranged a first valve *A* and a second valve *B*, both of which move in the same direction. They are subject to the closing pressure of the fluid which the valve controls, and also to a mechanical closing pressure from a spring *C*. The spindle *D* of the lower valve passes through the upper valve and its hollow spindle. The spindle *D* is connected to a lever *E* which turns on a pivot *F* and is extended to form an operating lever. The spindle *G* of the second valve is connected to a lever *J*, which turns about a fixed



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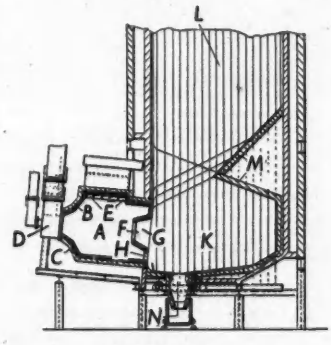
pivot *H*. An abutment is provided in the form of a collar on the spindle *D*. When the operating lever *E* is moved upwards the valve *A* is pulled up against its seat by an extra closing force and the compression spring acting through the lever *J* forces the valve *B* up against its seat. When the operating lever is pressed downwards the valve *A* is moved down from its seat and the abutment on its spindle contacting a cap on the top of the hollow spindle presses the valve *B* downwards away from its seat. The valve is claimed to ensure reliable closure because on both the valve members there is exerted a high mechanical closing force which is derived from the spring and transmitted through the levers and is not liable to be impaired by impurities such as boiler sludge or scale, since such impurities cannot reach the spring or levers. Different arrangements of valves and operating levers are also shown in the specification.—*March* 25, 1953.

STEAM GENERATORS

689,291 August 31, 1951.—COMBUSTION APPARATUS, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4.

The invention relates to a cyclone furnace arranged to discharge into a secondary combustion chamber in the gas flow path between the cyclone furnace and a radiation chamber, the combustion and radiation chambers, as well as the cyclone furnace, being fluid



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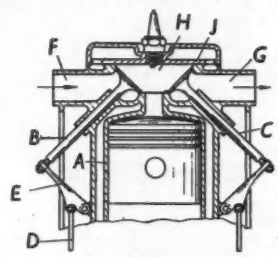
cooled. As shown in the drawing, a cyclone furnace *A* with refractory walls provided with cooling tubes *B* is formed at its fuel inlet end with a conical transition piece *C* terminating in a cylindrical projection *D* into which a stream of primary air and granular fuel may be introduced tangentially and at high velocity through an upper duct. Secondary air may be supplied through the nozzles *E*. The axis of the cyclone furnace is inclined downwards at a small angle towards its rear end, where the furnace is provided with a gas discharge opening *F* formed by a cooled tapering throat *G* and with a slag discharge opening *H*, both openings leading into a secondary combustion chamber *K*. During operation a temperature of 1600 deg. to 1800 deg. Cent. prevails in the cyclone furnace, so that the slag flows through the opening *H* as a thin liquid. A number of side-by-side cyclone furnaces may be arranged to discharge into the secondary combustion chamber. The combustion chamber *K* and a radiation chamber *L* are formed by dividing a space of rectangular cross section having upright walls lined with cooling tubes, by means of a wedge-shaped projection *M* extending forwards to about half the depth of the space and comprising tubes covered with refractory material. At the bottom of the chamber *K* is an opening *N* for the flow of liquid slag into a water trough. The arrangement of tubes and distributors is shown in the drawing.—*March* 25, 1953.

INTERNAL COMBUSTION ENGINES

689,480. August 3, 1950.—CYLINDER HEAD CONSTRUCTIONS, Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

In the drawing *A* is the water-cooled cylinder, *B* an inlet valve, and *C* an exhaust valve. The two poppet type valves are arranged, symmetrically and at an acute angle in relation to the cylinder axis, on the crankshaft side of the combustion space. The control of the valves is effected by means of a short push rod



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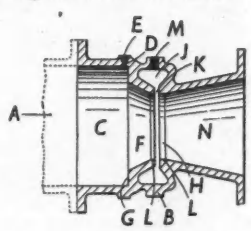
D and a lever *E*. Straight inlet and exhaust passages *F* and *G* are in line and opposite to each other at the combustion space *H*. The combustion space within the cylinder head has a hemispherical shape which is completed at the valve ports by the concave bases of the radially located valves. A flat cover *J* secured to the cylinder head is water cooled and carries an ignition plug. A modified design with a different method of operating the valves and a piston with a coned head is also shown in the specification.—*March* 25, 1953.

HYDRAULIC ENGINEERING

689,474. June 23, 1950.—LOW-LOSS VENTURI TUBE, George Kent, Ltd., 199/201, High Holborn, London, W.C.1 (*Inventor: Horace Edward Dall*).

The invention concerns an improved Venturi tube of the compact steep-angled type for insertion between an inlet and outlet pipe to produce a differential pressure for measurement of fluid flow. In the drawing the Venturi attachment *B* and inlet



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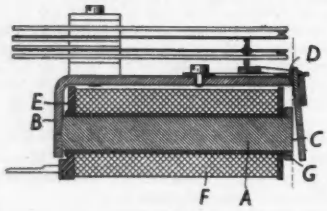
pipe *A* are shown. At the inlet end of the attachment *B* is a cylindrical chamber *C* of the same diameter as the inlet pipe *A*. In this chamber is a higher pressure offtake consisting of a comparatively narrow bore *D* and a comparatively wide tapping *E*. An inlet cone *F* has its mouth in an obstructing end wall *G* of the chamber *C*, and terminates in a throat *H*. An annular space *J* is formed in the main casing round the throat *H* and is connected to the space enclosed by the throat by an annular recess *K* formed in the throat wall leaving small lands *L* in the wall on either side of the recess *K* in order to avoid a sharp angle. A lower pressure offtake *M* is located in the space *J*. An outlet cone *N* extends from the throat *H* on the side remote from the inlet cone *F*. A modified design is also shown in the specification. Besides obtaining a stable discharge coefficient, the

improved Venturi tube is claimed to have an extremely low overall pressure loss averaging only 5 or 6 per cent of the differential pressure for tubes of medium proportion, a loss which is between two and three times less than for an orthodox type of Venturi tube.—*March* 25, 1953.

ELECTRICAL ENGINEERING

688,370. December 4, 1951.—ELECTRICAL RELAYS, Philips Electrical Industries, Ltd., Spencer House, South Place, Finsbury, London, E.C.2.

The relay as shown in the drawing has a straight core *A* which at its left-hand end engages the short limb of a right-angled yoke *B*. The core and yoke are electrically welded together over their entire surfaces of contact. The free end surfaces *C* and *D* are located in the same plane normal to the longitudinal axis



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of the core by grinding the assembled core and yoke. A coil former *E* having an energising coil *F* wound on it is slipped over the core. This coil former is secured in position at one end by the short limb of the yoke *B* and at the other end by an annular pole shoe *G* forced on to the end *C* of the core. The yoke and core, after being secured together by welding, are provided by electro-chemical means with a corrosion-resistant, passivated zinc layer.—*March* 4, 1953.

Technical Reports

Kiln Operator's Handbook. By W. C. Stevens and G. H. Pratt. London: H.M. Stationery Office. Price 10s. 6d.—This handbook has been prepared at the Forest Products Research Laboratory, and gives explanatory notes on the kiln drying of timber and on the operation of kilns. A comprehensive treatment of this subject is given including, for instance, notes on the principles of kiln design, operator's equipment and instruments, operation of a kiln, preparation of a load for kiln drying, drying schedules and kiln maintenance and testing. There are chapters on various aspects of moisture content and seasoning, and of special cases such as the kiln drying of veneers.

Development of an Instrument for Measurement of Total Oil Content of Boiler Feed Water and its Application to Samples Taken from Ships in Service (Report No. 69, R.B. 540). By A. S. T. Thomson, D.Sc., Ph.D., A.R.T.C., M.I.Mech.E.; A. W. Scott, B.Sc., Ph.D., A.R.T.C., M.I.Mech.E.; and A. M. Laird, B.Sc., A.R.T.C., A.M.I.Mech.E. The British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, London, W.1.—Details are given of the development of an instrument for determining the proportion of oil contained in the condensate from reciprocating engines, and the results of an investigation made on six vessels fitted with this form of machinery. The instrument developed at the Royal Technical College, Glasgow, makes use of the characteristic fluorescence of oil under ultra-violet light by comparing a solution of oil in ether, prepared from a sample of the feed water, with a previously prepared solution of known oil content under a mercury-vapour lamp. In the original form of the instrument, visual comparison of the samples was made, and an improved apparatus of this design was used for assessing the oil content of all the samples obtained from ships in service. A later form of the fluorescence comparator employs photo-electric cells and a galvanometer for measurement of the degree of fluorescence, and hence the oil content, of the feed water samples. It is considered that this instrument can be used with confidence; it eliminates the human element and has greater precision than the visual comparator. Samples were obtained from various positions in the feed systems of six ships, five of which were fitted with Scotch boilers and one with water-tube boilers. The water samples were taken from the air pump discharge and the outlet side of the filters, the intervals between sampling being determined by the filter changing routine. Details are given of the filtering materials used, the frequency of cleaning and the condition of filtering media before changing. The results of the tests on the samples indicate that the oil concentration in the condensate from orthodox triple-expansion engines does not exceed two parts per million (p.p.m.). This low value was found to vary very little from one ship to another, whether superheated steam and cylinder lubrication were used or not. In the six vessels on which tests were made the feed water, on entering the boilers, had oil contents which, in general, ranged from 0 to 1·5 p.p.m. Some oil is removed by the conventional form of filters, but it appears that they are largely ineffective for the very low oil concentrations which, according to these tests, occur in practice. An appendix describes the preparation of oil standards, the treatment of samples and the basic method of assessing oil content, while a second appendix contains comments by Captain (E) W. Gregson, R.N.R.

Launches and Trial Trips

SARSIA, biological research vessel; built by Philip and Son, Ltd., Dartmouth, for the Marine Biological Association of the United Kingdom; length between perpendiculars 115ft, breadth moulded 28ft, depth moulded 13ft; National Gas R4AUM6 diesel engine, 300 b.h.p. at 486 r.p.m., one 35kW diesel-driven generator, trawl winch and two hydrographic winches. Launch, April 14th.

ALGOL, dredger; built by Chantiers et Ateliers Augustin Normand for the national marine; length overall 46·3m, breadth moulded 8·5m, draught 2·28m, displacement 424 tons, speed 15 knots; two sets of gas turbines, 1800 s.h.p. Launch, April 15th.

IREX, oil tanker; built by Harland and Wolff, Ltd., for Sameiet Irex; length between perpendiculars 460ft, breadth moulded 59ft, depth moulded 34ft 10in, deadweight about 12,000 tons on 27ft. 6in draught; Harland-B. and W. single-acting, four-stroke diesel engine, six cylinders 740mm diameter, 1500mm stroke, 115 r.p.m., two single-ended multitubular boilers, one 50kW diesel-driven generator, two 50kW steam-driven generators. Launch, April 15th.

ALCYON, cargo ship; built by Smith's Dock Company, Ltd., for A/S Bruusgaard and A/S Acadia, Norway; length between perpendiculars 300ft, breadth moulded 46ft 7in, depth moulded to shelter deck 28ft 3in, deadweight 3550 tons on 19ft draught, speed 12 knots; one triple-expansion steam engine, 20in by 34in by 57in by 39in stroke, 1800 i.h.p. (trial), 1550 i.h.p. (service), two Scotch boilers supply steam at 220 lb per square inch and 580 deg. Fah. Launch, April 15th.

LONDON LOYALTY, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, deadweight 18,100 tons, draught 30ft 5¾in.; trial speed 15 knots; N.E.M.-Doxford single-acting, two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m., two 60kW steam-driven generators. Launch, April 16th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., May 6th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "Recent Advances in the Application of Electronics to Chemical Instrumentation," G. I. Hitchcox, 6.30 p.m.

Thurs., May 7th.—MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, Annual General Meeting, "The Development of the Radio and Electronics Industry in India," G. D. Clifford, 6.45 p.m.

CHEMICAL SOCIETY

Thurs., May 7th.—Burlington House, Piccadilly, London, W.1, Meeting for the Reading of Original Papers, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., May 12th.—LONDON CENTRE: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, Annual General Meeting, 6 p.m.——LIVERPOOL CENTRE: Merseyside and N. Wales Electricity Board's Service Centre, Whitechapel, Liverpool, 1, Annual General Meeting, "The Electrical Equipment of the Mersey Tunnel," C. C. Smith, 6 p.m.

Fri., May 15th.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., May 5th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, Ladies' Evening, "Running a Hotel," E. C. S. Price, 7 p.m.

Wed., May 6th.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Pumps and Pumping," J. B. Scivier, 7.30 p.m.——S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Modern Electrical Control Systems," 7.15 p.m.

Mon., May 11th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Textile Machinery," Robert Baird, 7.30 p.m.

Tues., May 12th.—E. LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, Film by British Ropes, Ltd., 7.15 p.m.——GLASGOW BRANCH: Works Visit to Paton and Baldwins, Ltd., Alloa, 2.15 p.m.

Wed., May 13th.—E. MIDLANDS BRANCH: Welbeck Hotel, Nottingham, "Industrial Applications of the Thickness Gauge," R. Y. Parry, 7 p.m.

Thurs., May 14th.—NEWCASTLE UPON TYNE BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Electrical Fuel Injection Equipment Applicable to Heavy Goods Vehicles and Contractors' Plant," H. J. Stoneman, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Sat., May 2nd.—The Christian Institute, 70, Bothwell Street, Glasgow, Scottish Regional Annual General Meeting and Members' Papers, 10.30 a.m.

Fri., May 15th.—George Hotel, Church Lane, London, N.W.9, "Planning in Practice," P. M. Garnier, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., May 12th.—85, Minories, London, E.C.3, "The Free Piston Engine," F. A. I. Muntz and Robert Huber, 5.30 p.m.

INSTITUTE OF NAVIGATION

Fri., May 15th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation and Oceanography," G. E. R. Deacon and G. S. Ritchie, 5 p.m.

INSTITUTE OF PETROLEUM

Wed., May 13th.—26, Portland Place, London, W.1, "Mechanical Handling in the Petroleum Industry," V. F. H. Samson and E. A. Reynolds, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., May 6th.—E. MIDLANDS CENTRE: Mechanics' Institute, Nottingham, Centre Annual General Meeting, 7.30 p.m.

Fri., May 8th.—S. WALES GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, "The Wilson Gearbox in the Field of Commercial Transport," A. Gordon Wilson, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 5th.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "The Design and Equipment of Modern Mechanised Marshalling Yards," R. E. Sadler, 5.30 p.m.

Thurs., May 7th.—STRUCTURAL AND BUILDING MEETING: Great George Street, Westminster, London, S.W.1, Discussion, "Would the Strength Grading of Ordinary Portland Cement be a Contribution to Structural Economy?" Introductory Notes by Edward Burke, L. J. Murdock, F. M. Lea and F. S. Snow, 5.30 p.m.

Tues., May 12th.—WORKS MEETING: Great George Street, Westminster, London, S.W.1, "Construction of Tignes Dam and Malgovert Tunnel," J. Pelletier, 5.30 p.m.

Thurs., May 14th.—MARITIME MEETING: Great George Street, Westminster, London, S.W.1, "Echo Sounding in Relation to Modern Harbour and Coastal Surveys," D. H. MacMillan, 5.30 p.m.——MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 6 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 4th.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Telemetering for System Operation," R. H. Dunn and C. H. Chambers, 6 p.m.

Tues., May 5th.—N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, Annual General Meeting, 6.30 p.m.——S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, 7 p.m.

Wed., May 6th.—S.E. SCOTLAND SUB-CENTRE: Heriot-Watt College, Chambers Street, Edinburgh, Annual General Meeting, 7 p.m.

Thurs., May 7th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "Research in the Electrical Manufacturing Industry," L. J. Davies, 5.30 p.m.

Wed., May 13th.—RADIO SECTION: Savoy Place, London, W.C.2, "Recent Work in France on New Types of Valve for the Highest Radio Frequencies," R. Warnecke and P. Guenard, 5.30 p.m.

Thurs., May 14th.—Savoy Place, London, W.C.2, Annual General Meeting, Corporate Members and Associates Only, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 1st.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "An Experimental Single-Stage, Air-Cooled Turbine," Part I, "Design of the Turbine and Manufacture of Some Experimental Internally Cooled Nozzles and Blades," J. Reeman and R. W. A. Buswell; Part II, "Research on the Performance of a Type of Internally Air-Cooled Turbine Blade," D. G. Ainley, 5.30 p.m.

Wed., May 6th.—LONDON GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1, Annual General Meeting, 6.30 p.m.——WESTERN BRANCH, GRADUATES' SECTION: College of Technology, Bristol, Annual General Meeting and Film Evening, 7 p.m.

Sat., May 9th.—SOUTHERN BRANCH, GRADUATES' SECTION: Visit to Transport Depot, Workshops and Power Station of the County Borough of Bournemouth Transport Department, 2.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., May 12th.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Engineering Accounting in the Post Office," H. L. Beck, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, May 1st.—YORKSHIRE GRADUATE SECTION: Works Visit to Dawson, Payne and Elliott, Ltd., Otley, 6.45 p.m.

Tues., May 12th.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Mechanised Inspection," J. Loxham, 7 p.m.——WOLVERHAMPTON GRADUATE SECTION: Star and Garter Royal Hotel, Victoria Street, Wolverhampton, Brains Trust on Production Engineering Problems, 7.30 p.m.

Fri., May 15th.—STOKE-ON-TRENT SECTION: Building Department, N. Staffordshire Technical College, Cauldon Place, Shelton, Stoke-on-Trent, "Education for Industrial Management," T. U. Matthew, 7.30 p.m.

INSTITUTION OF SANITARY ENGINEERS

Thurs., May 14th.—JOINT MEETING WITH THE INSTITUTION OF HIGHWAY ENGINEERS: Caxton Hall, Westminster, London, S.W.1, Discussion on "Reinstatement of Pipe Trenches—Public Utilities Street Works Act, 1950," Opened by S. M. Lovell and N. J. Tatman, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., May 13th.—WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, Annual General Meeting, 6.30 p.m.

Thurs., May 14th.—11, Upper Belgrave Street, London, S.W.1, "The Structural Aspect of Power Station Design in South Africa," G. M. Frost 6 p.m.

INSTITUTION OF WATER ENGINEERS

Wed. to Fri. May 13th to 15th.—Palace Hotel, Southend-on-Sea, Fifty-Eighth Summer General Meeting.

JUNIOR INSTITUTION OF ENGINEERS

Wed., May 6th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Notes on the Technique of Casting Aluminium Billets by the Semi-Continuous Process," E. Mitcheson, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., May 13th.—CORROSION GROUP: Burlington House, Piccadilly, London, W.1, Annual General Meeting, 6.30 p.m.